ASTRONOMY

May 1981
$2
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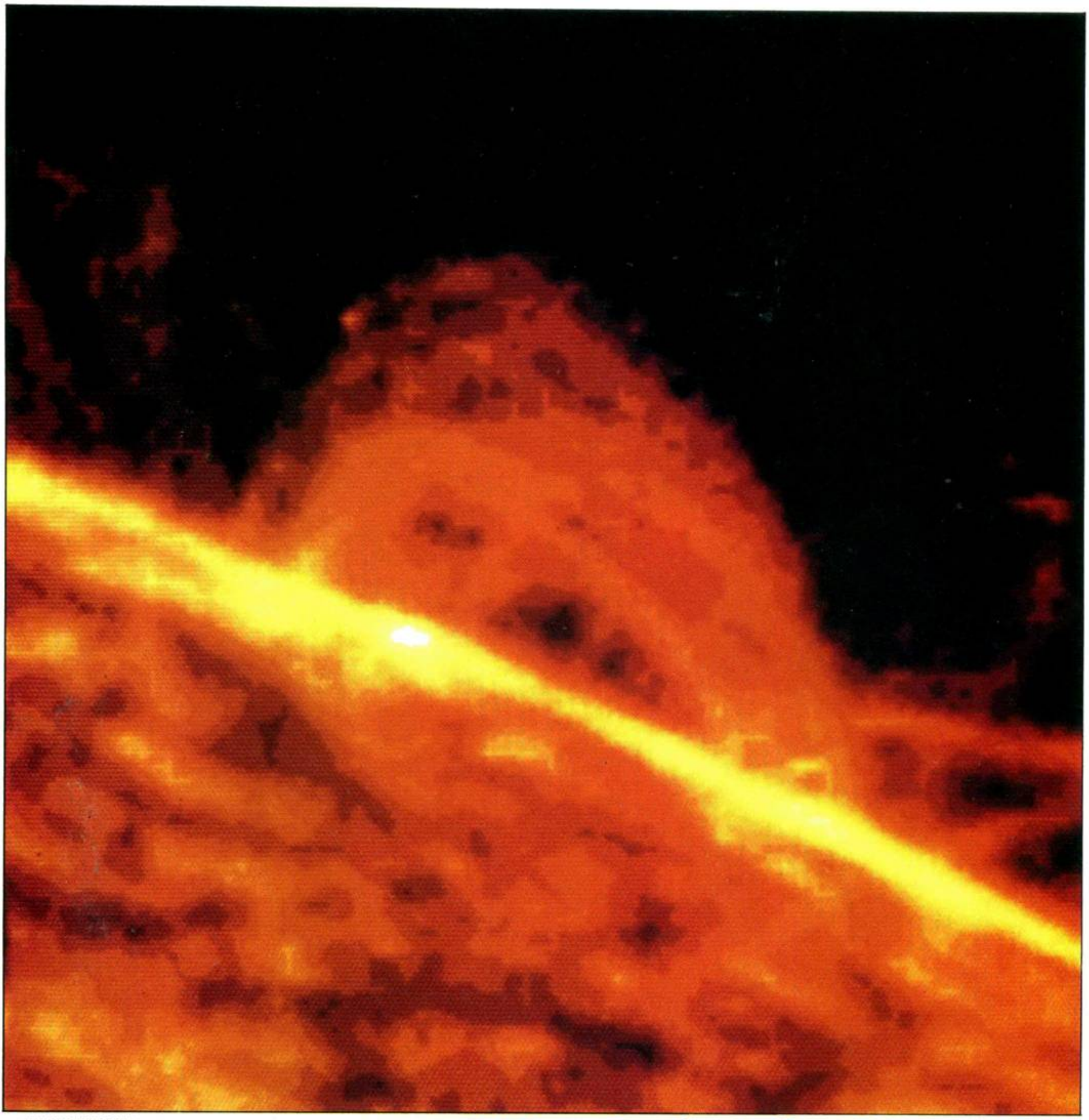
The Invisible Universe

Mercury: A Special Sight in the May Sky

Save the U.S. Space Program



A New Look at the Nearest Star

Meade System 2000

Think of the dimensions a truly research-quality instrument would add to your observing program.

Then consider moving up to the quality and performance of a Meade 4-inch or 8-inch Schmidt-Cassegrain. For Meade Schmidt-Cassegrains, both optically and mechanically, really are the finest instruments of their kind ever offered the serious observer and astrophotographer.

And, as parts of a wide-ranging system, they are instruments that will grow with your expanding horizons.

Standard Equipment: No other commercially available Schmidt-Cassegrains offer such a list of important technical advantages, much less as standard equipment included in the Base Price:

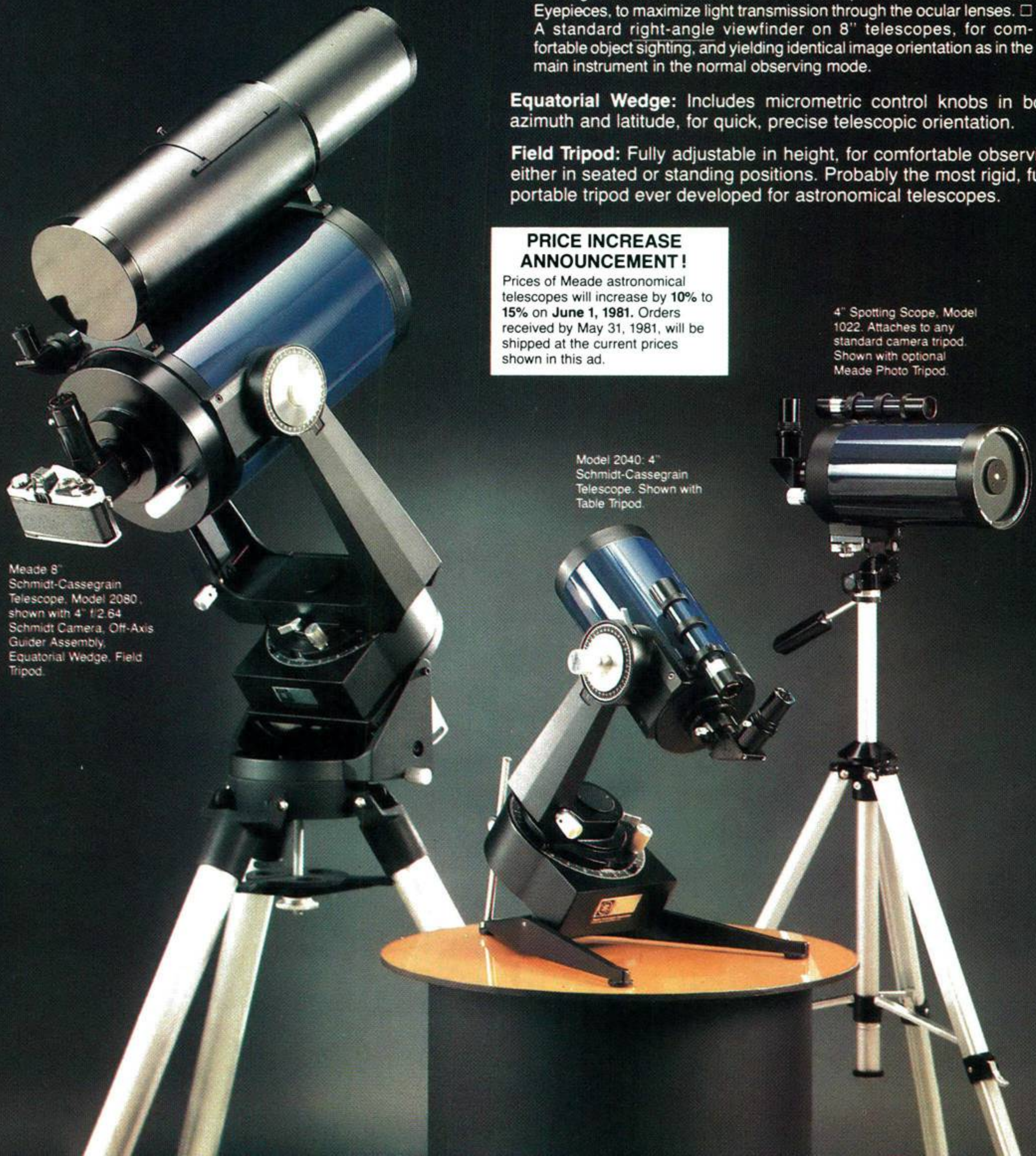
Worm gear drive systems, on both 4" and 8" models, for extremely low photo-visual periodic error and zero backlash. ☐ Ball bearings on both Declination and Polar Axes, permitting microsmooth tracking and precise balancing, even with the addition of auxiliary systems on the main telescope. ☐ On 8" models, an oversize 8.25" primary mirror, for a wider fully illuminated field, and to reduce the "edge darkening" of Schmidt-Cassegrains which use standard 8" diameter primaries. ☐ Multi-Coated Eyepieces, to maximize light transmission through the ocular lenses. ☐ A standard right-angle viewfinder on 8" telescopes, for comfortable object sighting, and yielding identical image orientation as in the main instrument in the normal observing mode.

Equatorial Wedge: Includes micrometric control knobs in both azimuth and latitude, for quick, precise telescopic orientation.

Field Tripod: Fully adjustable in height, for comfortable observing either in seated or standing positions. Probably the most rigid, fully portable tripod ever developed for astronomical telescopes.

PRICE INCREASE ANNOUNCEMENT!

Prices of Meade astronomical telescopes will increase by **10%** to **15%** on **June 1, 1981.** Orders received by May 31, 1981, will be shipped at the current prices shown in this ad.



4" Spotting Scope, Model 1022. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.

Model 2040: 4" Schmidt-Cassegrain Telescope. Shown with Table Tripod.

Meade 8" Schmidt-Cassegrain Telescope, Model 2080, shown with 4" f/2.64 Schmidt Camera, Off-Axis Guider Assembly, Equatorial Wedge, Field Tripod.

Schmidt-Cassegrains

The System: Perhaps most importantly of all, Meade System 2000 Schmidt-Cassegrains are part of a wide and versatile system: the amazing 4" f/2.64 Schmidt Camera; 4" Schmidt-Cassegrain Photo-Guide Telescope with Illuminated Reticle Eyepiece; Dual-Axis Drive Corrector, and more — all of which attach easily and directly to 8" models.

Aesthetic Design: In the beauty of their enameled deep-blue tube surfaces, in the fineness of their machine-tooled mechanical components, Meade System 2000 models are light years ahead of the competition. See the System 2000 for yourself, and no further explanation will be necessary.

Warranty: As with all Meade products, the System 2000 is fully covered by the Meade One-Year Limited Warranty. See the Meade catalog for full details on this no-risk protection of your investment.

PRICE LIST

Model 2040:	
4" Schmidt-Cassegrain Telescope with Fork Mount ...... Base Price	**$545**
Model 2080:	
8" Schmidt-Cassegrain Telescope with Fork Mount ...... Base Price	**785**
Equatorial Wedge 4"/8"	**50**
Field Tripod 4"/8"	**140**
Table Tripod 4"	**35**
Table Tripod 8"	**45**
Model 1020: 1000mm f/10 Telephoto Lens	**325**
Model 1022: 4" Spotting Scope	**395**
Meade Photo Tripod for Models 1020 or 1022	**50**
Model 2066: 4" f/2.64 Schmidt Camera	**435**

All prices include packing. Complete telescopes are packed in luggage-quality foam-lined carrying cases. All prices F.O.B. Costa Mesa, California. Calif. residents add 6% sales tax.

Catalog: Send $3.00 (Outside North America $5.00 for air mail) for your copy of the new 48-page Meade Color Catalog **No. 81-C**, with full details on Meade Schmidt-Cassegrains, Newtonian reflectors, refractors, accessories.

Orders: May be placed by mail, or by telephone at **(714) 556-2291**, or visit our Costa Mesa factory/showroom.

Meade Instruments Corporation
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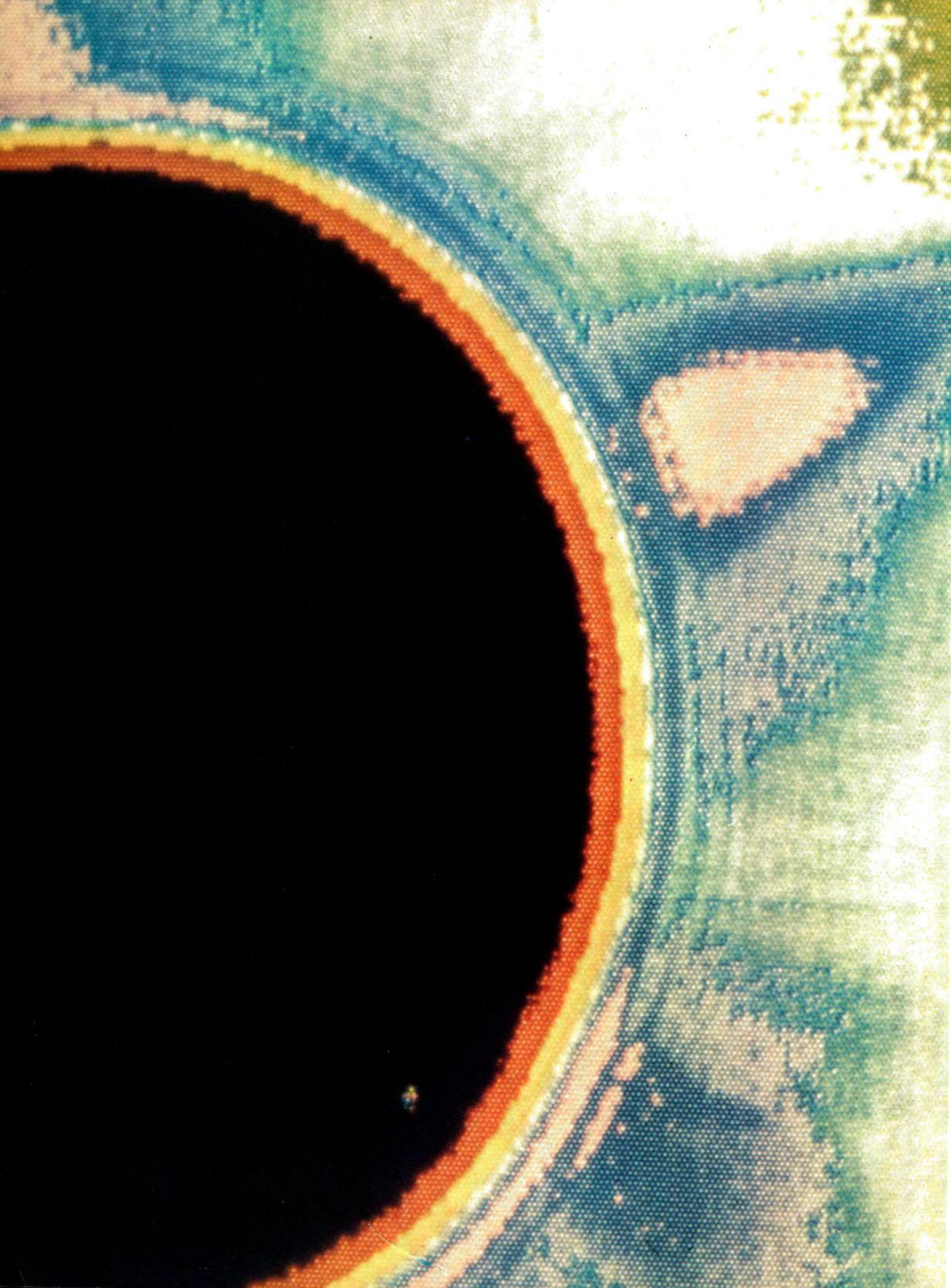
A partial listing of optional accessories for the System 2000 (see below) includes: ☐ Telecompressor (Multi-Coated) ☐ 2x Telenegative Amplifier ☐ Illuminated Reticle Guiding Eyepiece ☐ Erecting Prism ☐ 8 x 50mm Right-Angle Viewfinder ☐ Tele-Extender ☐ T-Adapter ☐ Off-Axis Guider ☐ 2" Diagonal ☐ 2" O.D. Wide-Angle Erfle 32mm Eyepiece ☐ Series 2 Orthoscopic and Modified Achromatic Eyepieces ☐ Research Grade Eyepieces ☐ Photo-Visual Color Filters (.965" and 1¼").

Note: See Meade Catalog for detailed specifications and standard-accessories listings of telescope models shown.

Model 2080: 8" Schmidt-Cassegrain Telescope, with Table Tripod, 4" Photo-Guide Telescope, Illuminated Reticle Eyepiece.

4" Schmidt-Cassegrain, Model 2040, with Equatorial Wedge and Field Tripod.

Model 1020: 1000mm f/10 Telephoto Lens. Attaches to any standard camera tripod. Shown with optional Meade Photo Tripod.



ASTRONOMY

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May 1981

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Cover: On March 27, 1980, the Solar Maximum Mission spacecraft imaged the magnetic arch shown on this month's cover. A few days later, on April 12, it relayed the picture of the solar corona on these pages. During its lifetime, the SMM spacecraft added profoundly to our knowlege of the nearest star, our Sun, as reported in this issue of ASTRONOMY. We also take you sightseeing on Jupiter's moon Io, investigate the possibility that the universe is filled with neutrinos, and keep you posted on this month's night sky. NASA photographs.

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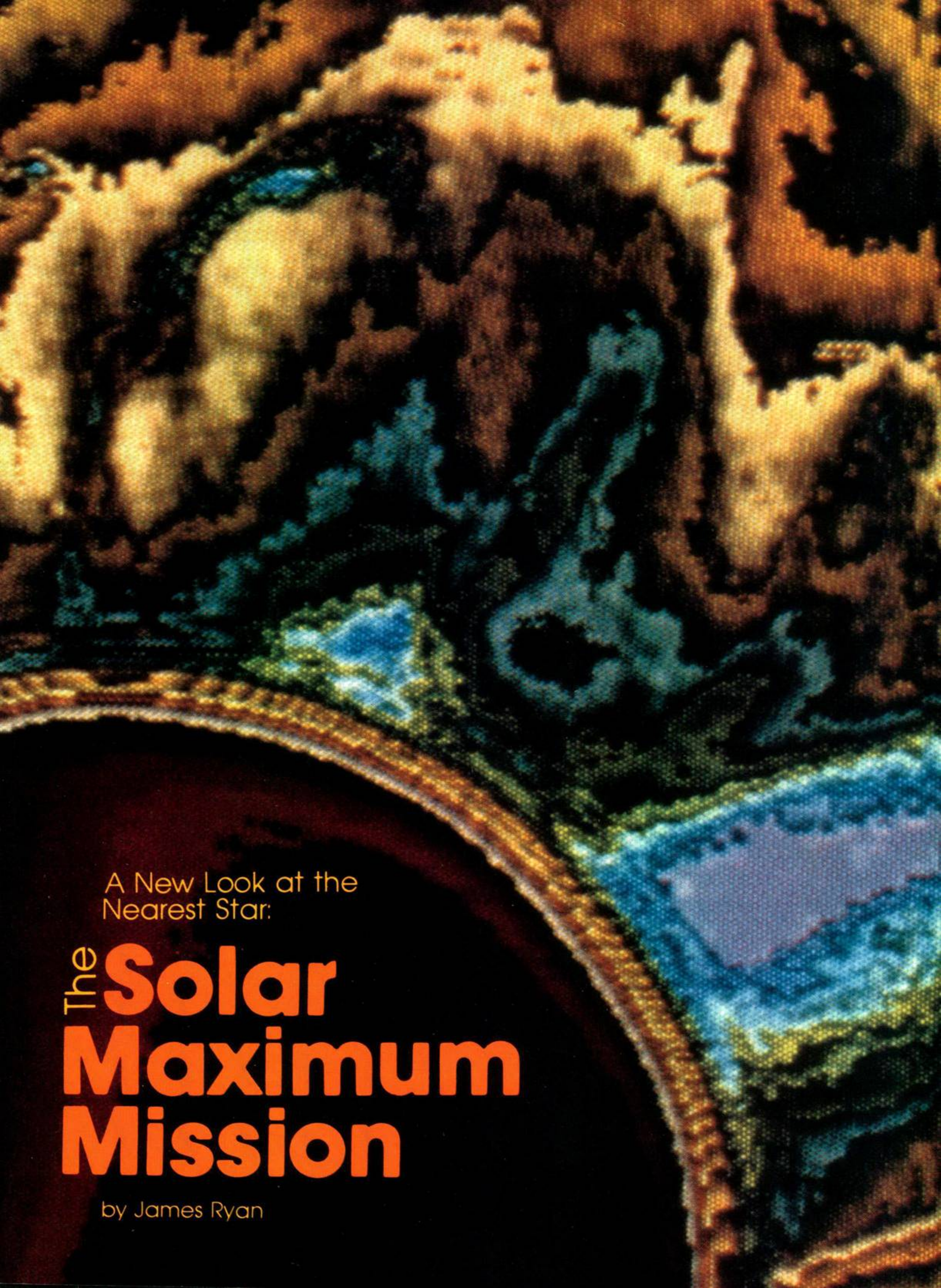
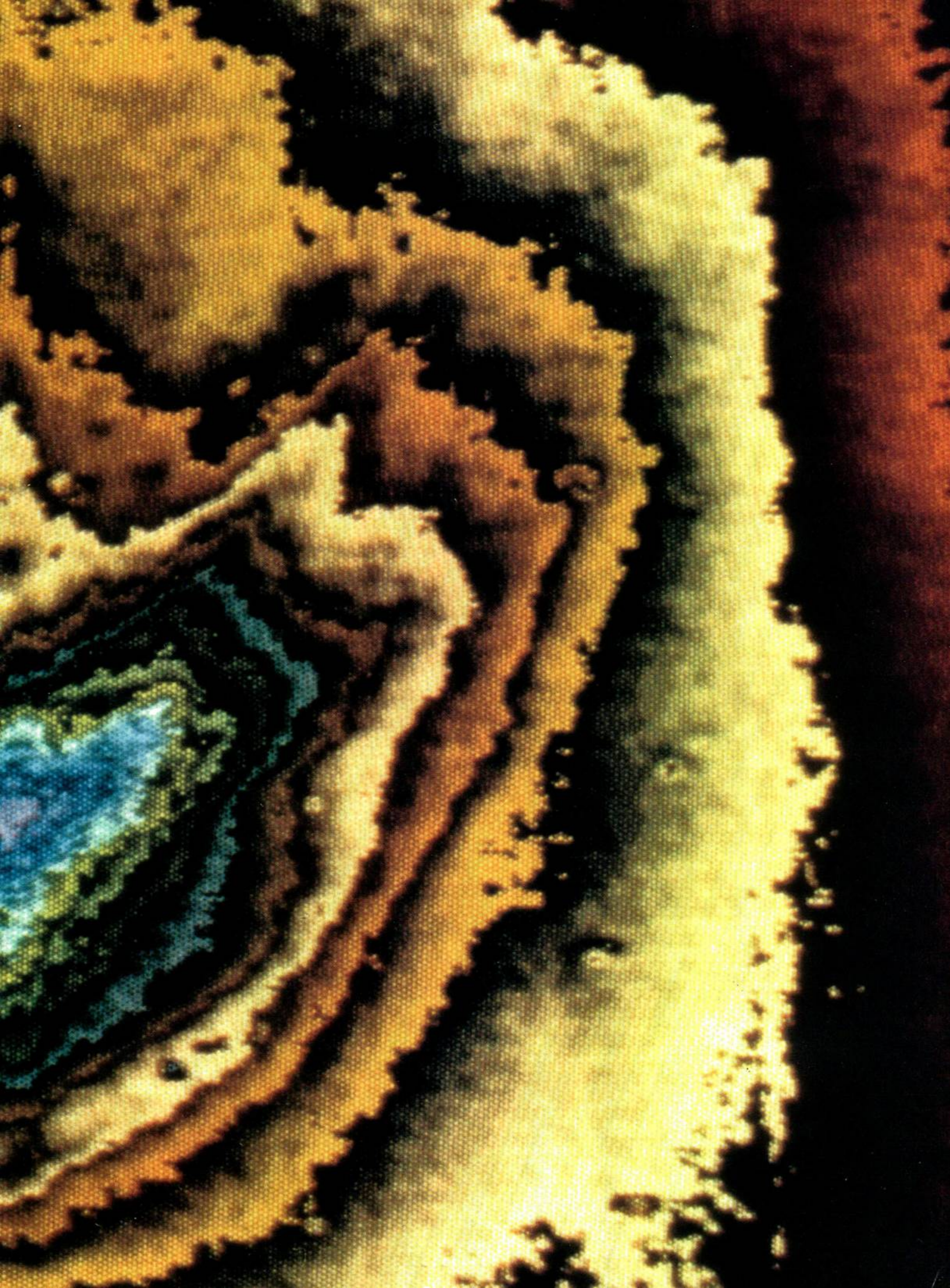
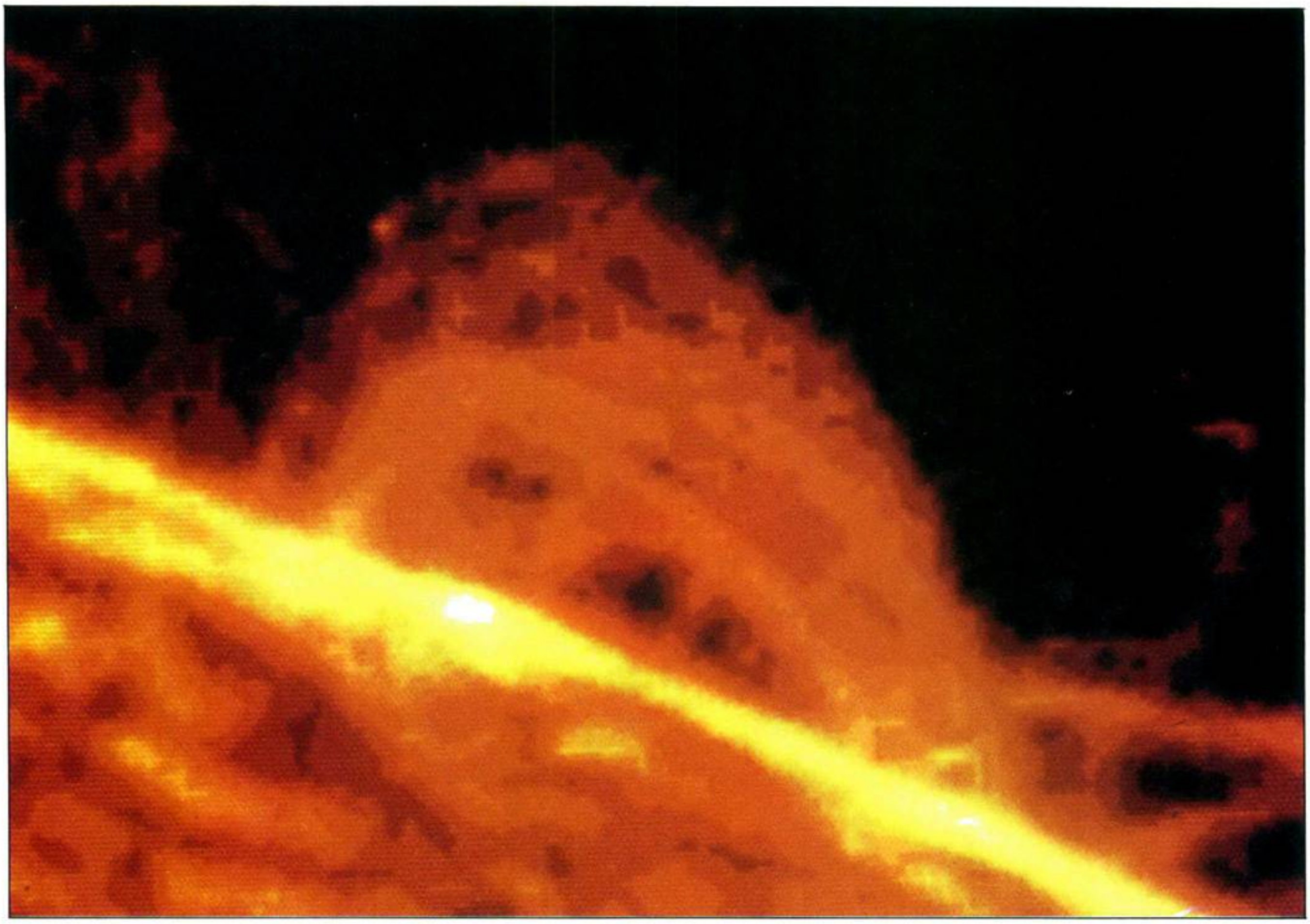


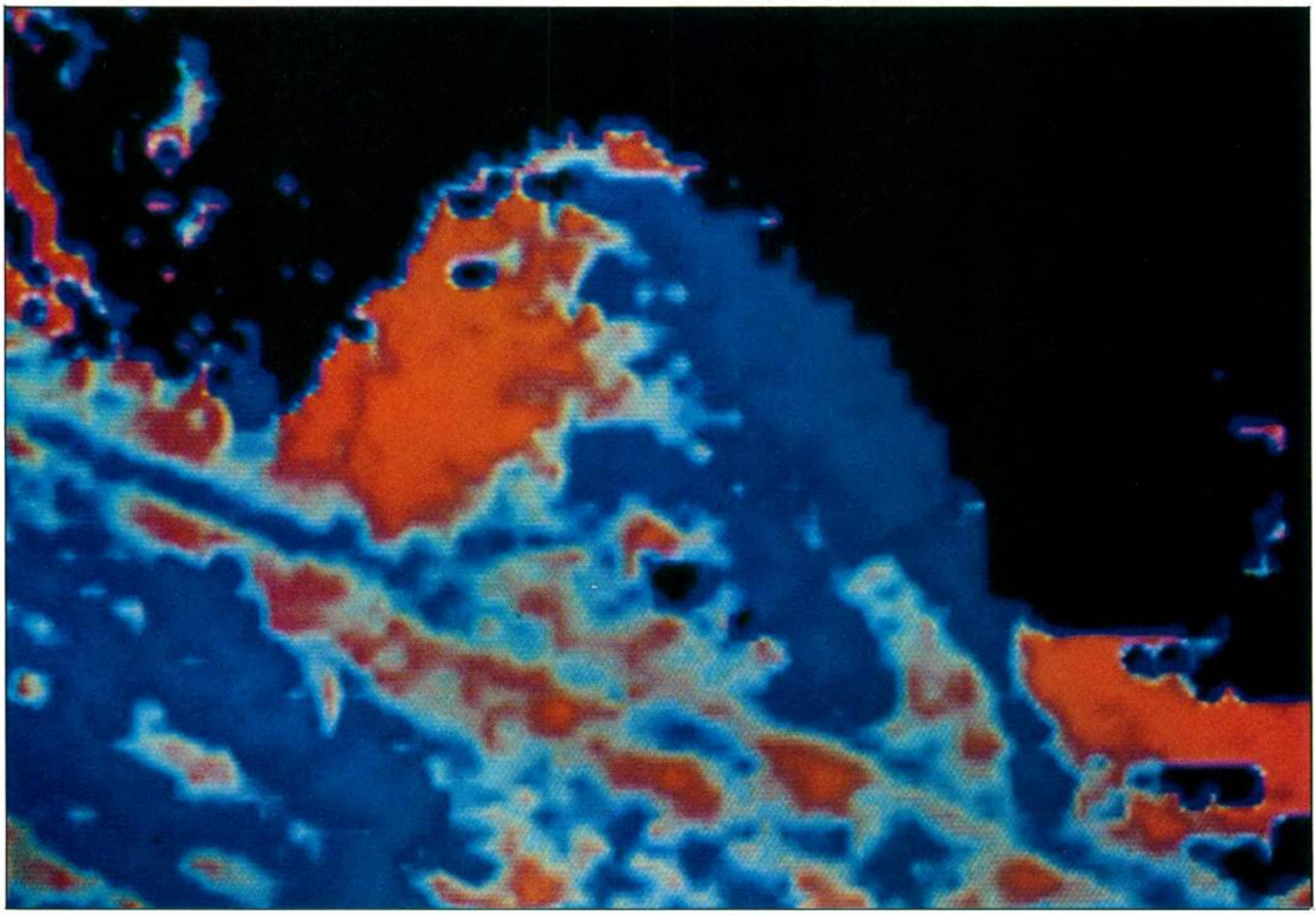
A New Look at the Nearest Star:

The Solar Maximum Mission

by James Ryan







Imagine how dull the sky would be if all the stars were identical and uniformly spaced, if all the galaxies were indistinguishable. Fortunately for us, though, the universe is not uniform, but extremely diverse. Everywhere we look we discover something new, and it is the variety of astronomical objects that holds our attention.

To astronomers, the challenge is to identify the things that make the differences and attempt to bring some order out of apparent chaos. For astrophysicists, the challenge is more specific: to understand the differences among stars in the universe by identifying the physical mechanisms which cause one star to develop and behave differently than another.

The first step in understanding stellar activity and development is to investigate and understand one particular star. From there, astrophysicists can extend many of the basic mechanisms to explain the activity and development of other stars. Fortunately, we have such a "sample" star — the Sun — right in our own backyard, astronomically speaking. Besides providing us with illumination and virtually all the energy we consume, it's also a convenient astrophysical laboratory where we can learn about many of the basic physical processes of the universe.

On Valentine's Day, February 14, 1980, NASA launched a satellite whose sole purpose was to study the Sun. The project is named the Solar Maximum Mission (SMM). With eight scientific instruments on board (see the box on page 10), this satellite successfully conducted detailed observations of the Sun in collaboration with other satellites and ground-based optical and radio observatories until its failure 10 months into the mission. And although the satellite did fail, it provided us with fresh insights into solar activity throughout its brief lifetime.

The Sun

On first inspection, the Sun appears as an extremely large sphere of gas — mostly hydrogen. The surface of the Sun which we see with the naked eye or with telescopes is the *photosphere*, with a temperature of roughly 5000° C (10,000° F).

Above the photosphere is a cooler, much less dense layer of the Sun called the *chromosphere*, with a temperature in the range of 4000° C. At this temperature and density, it is not visible to the naked eye because it sits above the much brighter photosphere. In the photosphere the proton and electron in hydrogen atoms are not bound together as a unit because it is too hot. However, the hydrogen in the cooler chromosphere is a complete, electrically neutral atom, and thus can emit Hα radiation, which is easily measured optically through a deep red filter.

Above the chromosphere is the *corona*. The corona is much more rarified than the chromosphere and, for reasons not fully understood, it's very, very much hotter — about 1,000,000° C or more. At that temperature all atoms are ionized (have lost their electrons), so the corona glows in soft X-rays. The X-rays are in the form of both *line radiation* (where the photons all have the same energy or wavelength) and *thermal radiation* which, unlike line radiation, is distributed over a wide and continuous range of energies or wavelengths. The electrons which produce the X-rays also produce erratic radio signals known as *noise*.

The *transition region*, between the corona and the chromosphere, is another hotbed of solar activity and a large fraction of the radiation from it lies in the ultraviolet range.

Thus, by looking at the Sun in different parts of the spectrum, we can observe the different components of the solar atmosphere — just as if we were peeling layers off an onion.

But the quiescent picture we have drawn of the Sun belies the true complexity of solar structure and activity. Telltale signatures of this complexity are the solar features called *sunspots* and, associated with them, *solar flares*. The main objective of the Solar Maximum Mission was to investigate one particularly important aspect of this activity: solar flares.

Solar Flares

Over the past several hundred years, solar astronomers have detected a distinct pattern in sunspot appearances, noting dramatic increases every 11 years. Scientists now associate this increase with the degree of solar activity and the frequency of solar flares. At the time of the SMM launch, the Sun was at such a maximum level of activity — hence the name of the mission.

Solar flares occur in so-called active regions, usually associated with sunspots. (Do not confuse flares with solar prominences — rising loops of cool gas also often associated with sunspots.) In these areas lie intense magnetic fields, often more than a thousand times the strength of the Earth's magnetic field. (See "Sunspots," ASTRONOMY, May 1980 and "Solar Magnetism: A New Look," ASTRONOMY, March 1981.) Flares occur during the disruption of these intense fields when magnetic energy is rapidly converted to other forms of energy.

You can picture the energy release in flares by imagining a rubber band representing the magnetic field in the flare region. As the magnetic field is twisted by the turbulent motion within the Sun, a point is reached when, like a rubber band, it can twist no further. It snaps — and the energy stored in the magnetic field is released. After the flare, the magnetic field is relaxed, or (in the jargon of solar physics) "reconfigured in a lower energy state."

The energy in a solar flare is released quickly and violently. A large flare, for example, may throw off thousands of times more energy than the United States consumes in a single year. This energy may take the form of fast subatomic particles, radiation, or the bulk motion of large amounts of matter. Enormous numbers of subatomic particles, mostly electrons and protons, are accelerated in the flare and some escape directly into interplanetary space.

Shock waves, a secondary flare phenomenon, may also blast particles into interplanetary space. Much like a surfer riding a wave, electrons and protons "ride" the expanding shock wave through the solar atmosphere and out into space. These

The images on the opposite page show a magnetic arch on the limb of the Sun in the ultraviolet light of three times ionized carbon. The red and blue in the lower photo represent the motion of matter moving away from and toward the observer (respectively) — generally up the loop from either side. These images were taken by the SMM spacecraft on March 27, 1980. NASA photos.

The SMM Experiments

The SMM satellite carried instruments to measure flare emissions over a wide range of the electromagnetic spectrum. Five of the eight instruments on board (FCS, BCS, HXIS, HXRBS, and GRE) provided sensitivity from low energy "soft" X-rays all the way up to high energy gamma rays. These instruments were:

FCS (Flat Crystal Spectrometer) — one half of the X-Ray Polychrometer (XRP), which was an imaging X-ray telescope sensitive to X-rays from 1.4A to 22.0A, and with a field of 7 x 7 arc-minutes. This telescope created images in seven spectral lines in X-rays representing plasmas at seven different temperatures.

BCS (Bent Crystal Spectrometer) — the other half of XRP. This instrument was a non-imaging spectrometer creating rapid energy or wavelength spectra over the entire solar active region in its field of view (in a wavelength range similar to that of FCS).

HXIS (Hard X-Ray Imaging Spectrometer) — a collimated imaging X-ray detector with a field of view of 6.5 x 6.5 arc-minutes and a resolution of 8 arc-seconds, sensitive to X-rays in the range of 3.5 to 30 KeV. (One KeV is the amount of energy gained by an electron in passing though 1000 volts.)

HXRBS (Hard X-Ray Burst Spectrometer) — measured in a non-imaging manner the X-rays in the range of 25 to 350 KeV. This instrument was capable of measuring intensity pulsations in the X-rays as short as 0.001 second.

GRE (Gamma Ray Experiment) — identical in concept to HXRBS but designed to operate in the range of 300 KeV to 10 MeV. (One MeV is the amount of energy an electron gains in passing through one million volts.) This instrument detected the highest energy gamma rays produced from electrons and in nuclear reactions.

The first of the three remaining instruments on board was *UVSP (Ultraviolet Spectrometer and Polarimeter)*, which measured the radiation from the heated gas around the flare from a few thousand to a few million degrees. UVSP was an ultraviolet telescope sensitive from 1100A to 3000A with a field of view of 4 x 4 arc-minutes. Temperature, velocity, density, and magnetic field strength could be measured in this manner.

Additionally, the SMM had a coronograph instrument *(C/P — Coronograph Polarimeter)* — a white-light optical telescope with an occulting disk extending to 1.5 times the radius of the Sun's image to create its own solar eclipse. The instrument was designed to observe the flare-produced disturbances in the farthest reaches of the Sun's atmosphere, or corona. The corona could be observed in white light or through any of several filters (such as a hydrogen Balmer, an oxygen green light, or a neutral polarizing filter).

Although the SMM was primarily designed to observe solar flares, three instruments had the capability to do research on the non-flaring "quiet" Sun. In addition to C/P and UVSP, these included the last instrument on board — ACRIM. *ACRIM (Active Cavity Radiometer Irradiance Monitor)* was a group of three cavities fully absorbing and measuring the Sun's radiant energy from the far ultraviolet to the far infrared. ACRIM allowed us to measure the total energy radiated from the Sun to an accuracy better than 0.1%.

Of all the eight instruments, four (where technology allowed) — C/P, UVSP, FCS, HXIS — produced images of a portion of the Sun or, in effect, movies.

particles are often detected by interplanetary space probes as they move out of the solar system.

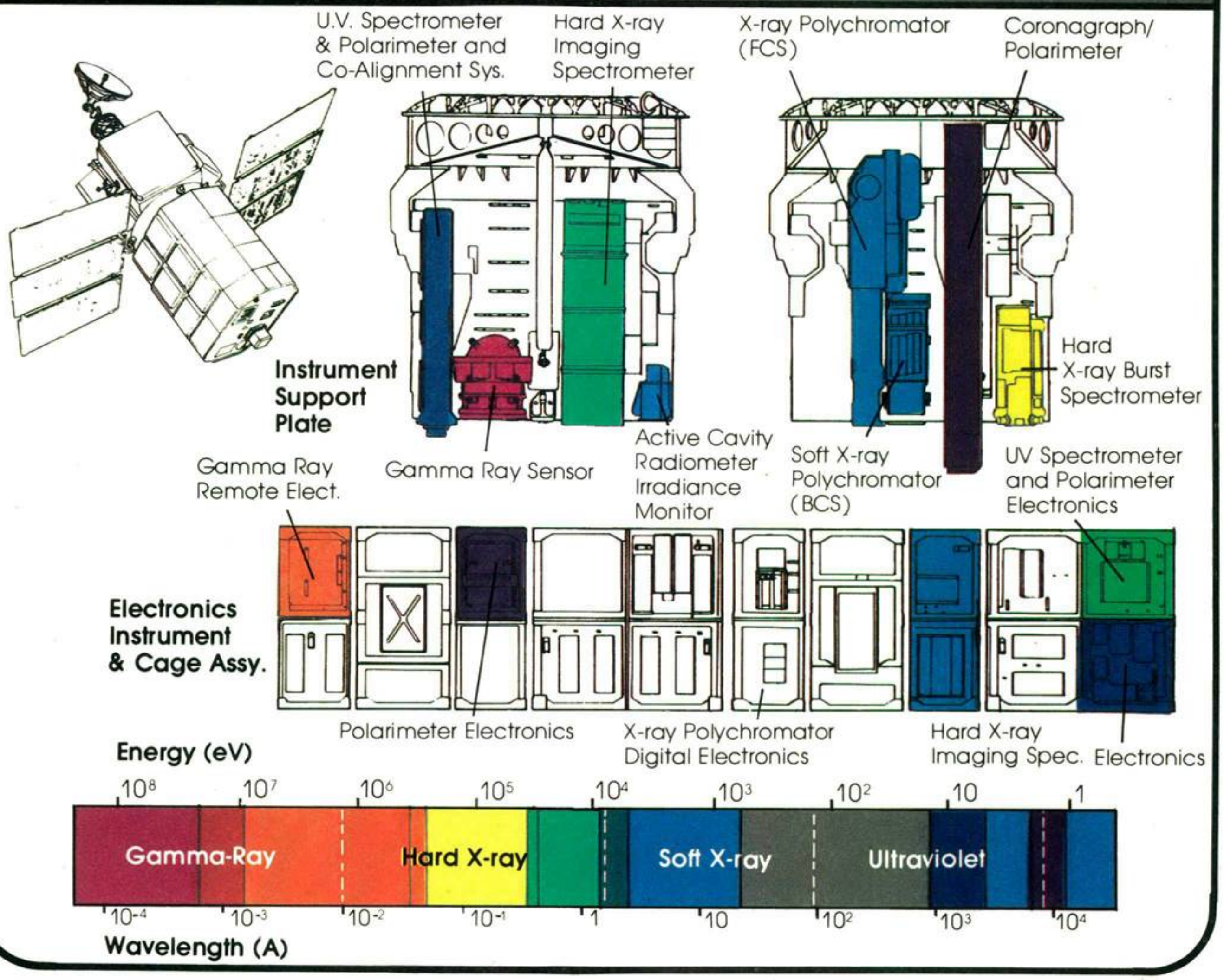
The energy of the flare-ejected particles is equivalent to what they would obtain in passing through an electric field of hundreds of thousands or even millions of volts in a particle accelerator and they attain a significant fraction of the speed of light. In the largest and most intense flares, particles can be accelerated up to cosmic ray energies, which we can measure on Earth.

We can indirectly measure those particles accelerated in the flare which do not escape the Sun by the radiation they emit when they interact with magnetic fields or solar matter. The interaction of electrons with magnetic fields produces radio and microwave noise. Collisions of these electrons with other matter produce so-called *hard* or *high energy X-rays* similar to medical X-rays and, in some cases, the even more energetic *gamma rays* — the highest energy electromagnetic radiation known. The gamma rays appear with certain specific energies — energies which depend on the composition of matter in the flare neighborhood. Scientists refer to these gamma rays as *gamma line radiation*.

The flare process also heats *plasmas* (gases composed of charged particles such as electrons and protons not combined into atoms) in small regions to very high temperatures — hundreds of millions of degrees — and much larger regions to temperatures millions of degrees. The high-temperature plasmas emit hard X-rays, while the cooler plasmas (i.e., those at one million or so degrees) emit so-called soft or low energy X-rays with energies around one thousand electron volts. In the soft X-ray range, much of the radiation appears in the form of line radiation at discrete, specific energies or wavelengths which, as in the case of gamma line radiation, are peculiar to the composition of the plasma.

Both gamma and X-ray line radiation come from carbon, oxygen, silicon, and other elements which comprise less than 1% of the Sun. By studying specific X-ray emissions, comparing their strengths and analyzing how they vary with time, we can determine the size, temperature, and rate of heating of the plasmas in a solar flare. The hard X-rays from the small, very hot plasmas rise and fall within seconds or minutes, while the soft X-rays from the larger and cooler plasmas take minutes or hours to reach their

The SMM Satellite


U.V. Spectrometer & Polarimeter and Co-Alignment Sys.
Hard X-ray Imaging Spectrometer
X-ray Polychromator (FCS)
Coronagraph/ Polarimeter
Hard X-ray Burst Spectrometer
Instrument Support Plate
Active Cavity Radiometer Irradiance Monitor
Soft X-ray Polychromator (BCS)
UV Spectrometer and Polarimeter Electronics
Gamma Ray Remote Elect.
Gamma Ray Sensor
Electronics Instrument & Cage Assy.
Polarimeter Electronics
X-ray Polychromator Digital Electronics
Hard X-ray Imaging Spec. Electronics
Energy (eV)
10⁸
10⁷
10⁶
10⁵
10⁴
10³
10²
10
1
Gamma-Ray
Hard X-ray
Soft X-ray
Ultraviolet
10⁻⁴
10⁻³
10⁻²
10⁻¹
1
10
10²
10³
10⁴
Wavelength (A)

peak and fall back to their normal low level. Flares often give a kick to large amounts of gas around them — and much of their energy appears as the motion of this gas in the solar atmosphere.

We often feel the effects of all these phenomena on or near Earth. From a large flare, the ejected particles, X-rays, and gamma rays can cause disruptions of radio communications, extensive auroral displays at high latitudes, and, in some cases, local disruption of electric power. In addition, the radiation during the largest flares could be lethal to astronauts. Thus for practical as well as scientific reasons, it is beneficial to study and understand these violent happenings on our neighbor, the Sun. Thus, the Solar Maximum Mission.

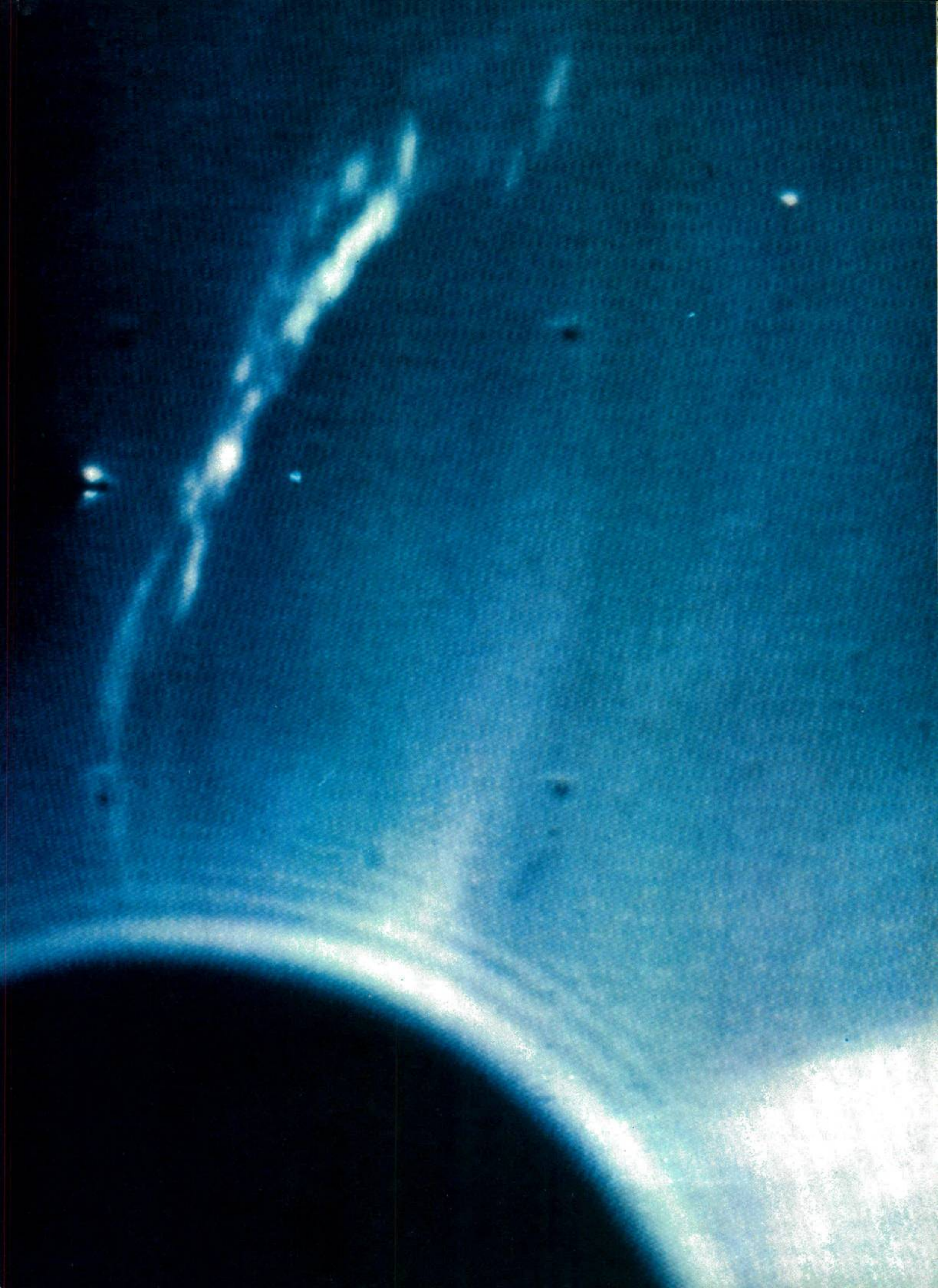
Not only are we interested in all the very energetic emissions from a solar flare, but we also want to know where and how a solar flare occurs. To learn these facts, we need "image data" — in effect, pictures of the event. This is where the SMM satellite proved especially valuable. Since solar flares emit such a wide range of electromagnetic radiation, we must photograph the flare in as many parts of the spectrum as possible. Radiation from different parts of the spectrum arises not only from different layers in the solar atmosphere, each of which is at a different temperature, but also from different physical processes.

Our present understanding of solar flares tells us that the release of magnetic energy occurs in the corona. Consequently, we see the greatest effect of solar flares or solar activity in the nearby layers — the corona, the transition region, and the chromosphere. As flares appear in the Hα line radiation emitted from the chromosphere — only rarely do we see a so-called *white-light flare*, which is a solar flare in the light of the photosphere.

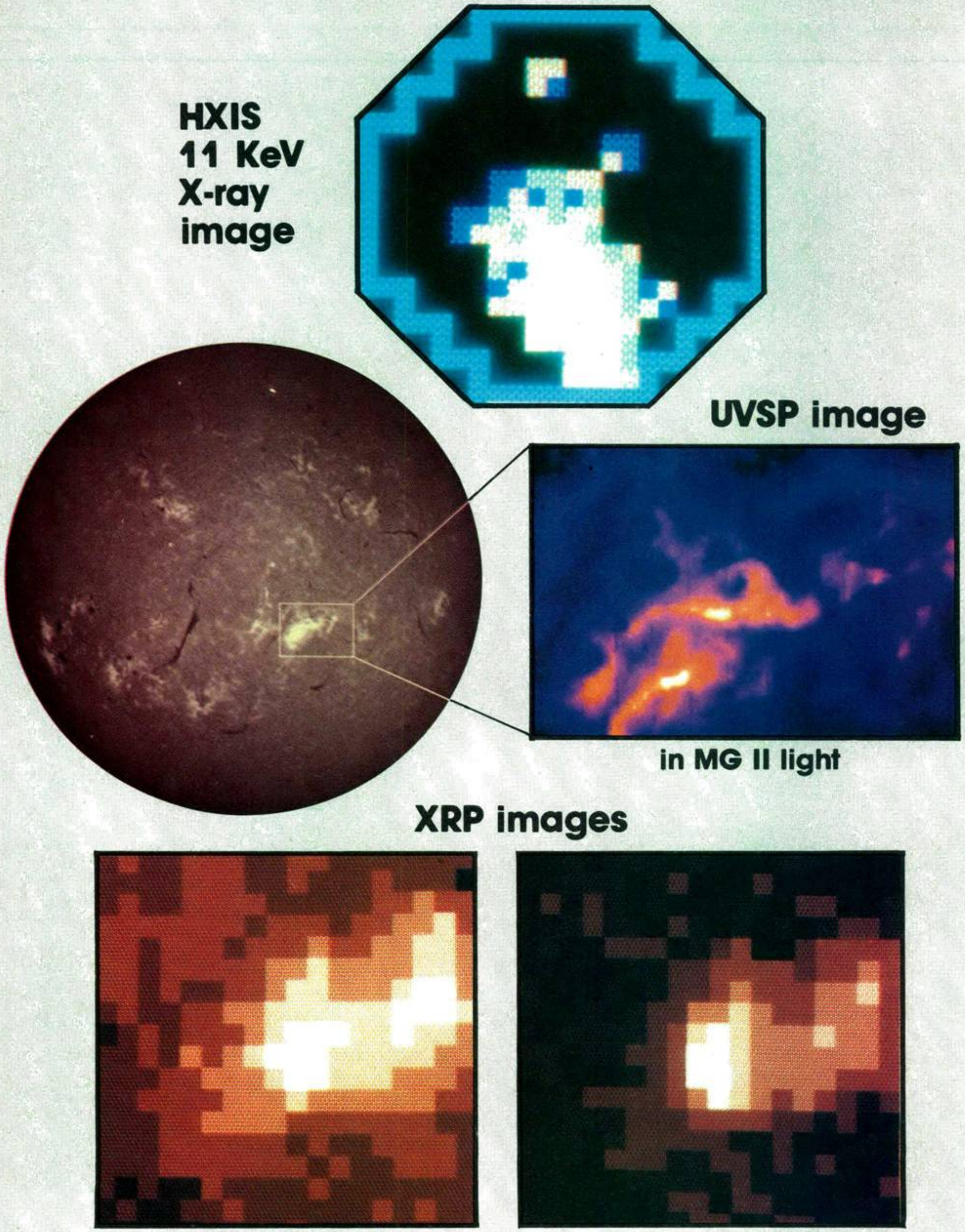
A sequence of photographs of a solar flare taken from the SMM in a particular part of the spectrum shows how a flare develops in a particular layer of the solar atmosphere. If a flare occurs on the limb (the

Page 12 & 13:

The coronagraph/polarimeter instrument aboard the SMM satellite recorded, in H-alpha light, this coronal transient on May 5, 1980. Caused by a flare, this large feature extended far into space and was much cooler than the surrounding corona it invaded. NASA photo.



SMM Views of the May 21 Flare



HXIS 11 KeV X-ray image

UVSP image

in MG II light

XRP images

taken in 0 VIII

taken in Mg XI

visible edge) of the Sun, we see it in profile. This provides valuable information since flares seem to be associated with magnetic loops sitting above the photosphere — like bridges between two magnetic areas in the same active region on the surface of the Sun.

A unique and very valuable feature of the SMM was that all the observations made by its instruments were made simultaneously. Much more can be learned if a flare is observed at the same time by as many instruments as possible. In the past, measurements similar to those performed by a single SMM instrument had been conducted by other spacecraft but never done together for a single complementary study.

Additionally, radio and optical observatories on Earth and particle detectors on other spacecraft participated in this joint effort. Just as a judge and a jury would certainly prefer as many eyewitnesses to a crime from as many different perspectives as possible, the designers of the SMM tried to provide a complete picture in as many wavelengths as possible.

Observations

In order to perform such coordinated observations, representative scientists from each experiment team met each day to decide which active region of the Sun was to be observed. With the solar forecast provided by National Oceanic and Atmospheric Administration (NOAA) and with an awareness of the mission priorities, the planning committee weighed the advantages and disadvantages of observing various active regions on the solar disk. Often their planning was successful and they chose a region which flared.

The average solar activity after the launch of the satellite was unexpectedly low for a solar maximum cycle, yet in this time there still were a number of flares which lent themselves to detailed analysis. The flares most favorable for study were those in the field of view of the so-called "pointed instruments" — those which could be aimed or pointed at specific regions on the Sun. (Flares which occurred outside the narrow field of view of these instruments were "seen" by only a few of the experiments.) Two flares especially suitable for detailed observations occurred on April 30 and May 21 of last year.

On April 30, an underlying magnetic arch rose from below to interact with an overlying arch. At the time of the impact, HXIS and HXRBS (see the box on page 10 for descriptions of the instruments onboard) instruments registered a rapid increase or burst of X-rays. The rising magnetic feature was seen in Hα radiation by Holloman Air Force Base Observatory and by UVSP. After the X-ray burst, HXIS observed additional X-ray emission from a "tongue" of material even farther above the solar surface. This material became bright in X-rays because energetic electrons were streaming from the site of the original X-ray burst. The magnetic field channeled electrons into this tongue, and the collision of the electrons with the matter in the tongue produced the postflare X-rays.

The Hα images also showed a tongue-like feature developing after the X-ray burst and reaching out to about 40,000 kilometers — about 2½ times the diameter of Earth. Meanwhile, radio astronomers at Owens Valley, California, also observed this flare and determined the magnetic field strength on the flare region. The soft X-ray data from SMM indicated that early in the flare there was a violent tubulent motion in the gas of the flare region, with random velocities of roughly 200 kilometers per second.

By piecing together these and other facts, we know rather precisely what happened in that flare. It began when two magnetic loops with field strengths over 300 times Earth's collided about 15,000 kilometers above the solar surface, producing a number of very energetic electrons. This in turn produced a burst of hard X-rays. The intense heating at that moment generated violent and turbulent motion in the 20 million degree gas. After the flare, the energetic electrons escaped within seconds into a magnetically confined region about 40,000 kilometers above the Sun.

The April 30 event marked the first extensive and coordinated observation of a solar flare, and produced the first *direct* evidence that the interaction of magnetic fields can cause a flare. The ground-based optical and radio observatories also contributed significant observations.

Another joint flare observation occurred on May 21, 1980. This time the flare was a classic *two ribbon* flare, rather large by Hα and soft X-ray standards. "Ribbons" are intense magnetic structures which become linked during a flare, allowing a transfer of energy from the magnetic field to thermal and energetic electrons. The electromagnetic radiation from the May 21 flare so disturbed the Earth's ionosphere that radio communications in a broad band were lost for over half an hour. Another effect on Earth was a nine-hour geomagnetic storm produced by a glancing blast of solar plasma from the flare.

The May 21 event produced great numbers of hard X-rays and some low-energy gamma rays, all created by electrons. Noticeably absent was any sign of an acceleration of atomic nuclei, which would have been "seen" by the GRE. This has forced solar physicists to reconsider their ideas about the role nuclear acceleration plays in solar flares.

The X-ray spectrum of the May 21 event as measured by the HXRBS indicated a temperature in excess of 100 million degrees in the flare core. Four bursts of X-rays were detected, with the largest ones occurring in the first few tens of seconds. During the early intense spikes of the flare, HXIS also measured large X-ray bursts emanating from different pairs of points or small regions at different times. (One pair of bright points is shown in the photo on the opposite page.)

Scientists theorize that, in structures like the magnetic arch of the April 30 flare, electrons are accelerated to high energies near the top of the arch, and within a second, stream down both sides of the arch. When they hit the much denser matter at or just above the photosphere, some 30 to 50 thousand kilometers below the top of the arch, the impact produces a pair of bright X-ray points at the feet of the arch. In the May 21 event, two pairs of points brightened at different times, but at nearly the same time as the bursts of the hardest X-rays.

According to this theory, there were at least two loops or arches over the region, each producing a

SMM Satellite Fails

The SMM satellite was scheduled to remain operational through 1981, and was designed and built for an easy in-orbit retrieval by the Space Shuttle for possible future use. Before such a recovery, the instruments would have continued to collect and transmit valuable solar data.

But on November 13, 1980, the attitude control fuses in the spacecraft began to blow. Apparently the tiny fuses had degraded in the vacuum of space to the point where they could no longer carry the current load placed on them. (Planners had originally considered using heavier duty fuses, but the idea somehow got lost in a bureaucratic shuffle.) By December 11, three of the four attitude controls were inoperative, and the spacecraft was left "floundering around," as one scientist put it, no longer able to point accurately at the Sun.

Although the SMM did not achieve its fully operational design lifetime of one year, data return was so successful that NASA declared it a "formal mission success" even before the mission ended.

subflare of its own — first one, then the other — a unique observation. Recent microwave observations of other flares during the first impulsive stage showed a brightening at the top of the loop or arch rather than at the feet of the arch. If SMM and the microwave observatories on the ground could have observed the same flare, this apparent discrepancy could have been resolved.

Significant discoveries have also been made by individual experiments alone. The GRE and HXRBS detected a large number of hard X-rays and gamma rays from a flare on June 7, 1980. The emission came in the form of seven intense bursts, each about 5 seconds long, separated by the same amount of time. Many of the gamma rays were emitted at specific energies, a clear signature that protons collided with the existing carbon, oxygen, and other heavy elements in the region, producing nuclear reactions with these gamma rays. One particular nuclear line, caused by the production of heavy hydrogen (deuterium) from protons and neutrons emitted by other nuclear reactions, was also detected.

Suprisingly, these signatures of nuclear reactions were at least ten times as strong as anything that could have been measured from the flare on May 21, yet this flare was only about half the size of that of May 21 as measured by the usual optical and soft X-ray methods. Several other flares have produced gamma rays, and there seems to be little correlation with size. In other words, the largest flares do not necessarily produce the most gamma rays. Scientists are now investigating theories for nuclear acceleration which would allow such high acceleration in moderate-sized flares without necessarily happening in large ones.

During non-flaring times, the ultraviolet experiment (UVSP) detected a bobbing motion — oscillations — in the Sun's atmosphere just below the corona. They occurred over sunspots where the magnetic field emerging from the solar surface is strong.

The coronograph (C/P) has "seen" many so-called coronal transients in the higher atmosphere of the Sun produced by solar flares at much lower altitudes. One such transient (pages 12 and 13) started first as a loop-like structure of immense size, hundreds of thousands of kilometers across, then "blew out" in a whip-like motion into a nearly linear feature.

In another flare on April 7, 1980, a similar event took place. From the combined data of C/P and the radioheliograph in Culgoora, Australia, the experiment scientists were able to conclude that the energy of the moving material (at speeds approaching 1000 km/sec) in the coronal transient was more than ten times the energy released in the form of radiation from optical to X-ray energies. Larger still was the energy in the magnetic field directing the motion of the material. In this case, most of the energy associated with the flare was in the form of this secondary phenomenon of the transient higher in the corona, while other flares as seen on the limb produced no disturbance in the corona. Here again, as with nuclear gamma ray production, the scientists were surprised by the diversity of phenomena they saw in solar flares.

During April 1980, the total radiation monitor, ACRIM, detected a 0.2% drop in the total output energy of the Sun lasting for about four days and then returning to its normal value within a week or so. This dip coincided with the rapid growth of a sunspot group near the limb of the Sun, and was far greater than what would be expected from the normal darkening of the sunspots.

Only now, since the SMM spacecraft has "died" do scientists have time to extract all the science from the data. Here we have looked at only a fraction of the data obtained before July of last year. This information will doubtless continue to surprise the scientists who analyze it, most likely raising as many questions about the behavior of the Sun as they answer — an inevitable consequence of the learning process.

Even though the satellite is now only a piece of space debris, data from the Solar Maximum Mission will continue to provide new insights into this very nearby star. At the end of this mission, our understanding of the Sun will be impressive — a large fraction of our total knowledge of stellar physics. The Sun is just one of trillions of stars of many types in the sky, but the great number of unanswered questions about our nearest stellar neighbor tells us there is much homework to be done. The night sky with its wide variety of objects will prove to be a fascinating place for some time yet.

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The View from Io

by William K. Hartmann

With the help of images from Voyager, we can take an imaginary walk on the surface of Io, the jovian moon considered the strangest body in our solar system.

What will those pioneers see? — those lucky humans who step out of the first manned lander on Io and shuffle across the cindery surface to place a seismograph on some sulfurous outcrop. We've already learned that the skies and surface of Io hold some of the most stunning visual effects in the solar system, though few of us will live long enough to see the pictures from the first robot lander. But, from the preliminary reconnaissance of the Voyager missions to Jupiter, we now know enough that we can travel to Io via our imagination.

What distinguishes Io and makes it a world of dramatic sky and landscape? First and foremost, it simply isn't like other planets or the rest of Jupiter's moons. Even though they turned out to be strange worlds (at least by the standards of those of us who

NASA/JPL photo.

grew up breathing air, walking on a surface of silicate soil, dangling our toes in liquid water pools), nothing had prepared us for Io: it may qualify as the most bizarre of the nearly two dozen worlds we've seen at close range.

From space, Io is mottled with orange, yellow, red, and white patches, and pocked with blackish spots. One Voyager team scientist remarked that although he didn't know what was wrong with Io, it looked as though it could be fixed with a shot of penicillin. Another remarked that Io looks like one of those planets we used to laugh at in grade "B" sci-fi thrillers.

Io has volcanos. Voyager 1 "saw" a total of eight plumes shooting 70 to 280 kilometers above the surface, raining material across as much as 1000 kilometers of Io's surface. The plumes erupt — with incredible violence — from Io's volcanic vents at velocities of 1800 to 3600 kilometers per hour. Four months later, when Voyager 2 flew by Io, at least six of these volcanos were still active.

The blackish colored spots are volcanic calderas, the irregularly-shaped holes left by many volcanic eruptions. Flows of vari-colored material have poured onto the surface and spread across large areas. So many simultaneous eruptions — at a level of volcanic activity unheard of on Earth — qualify Io as the most volcanic body in the solar system.

Spectra and other evidence indicate that the surface color comes not from the ice or rock of other worlds, but from sulfur and sulfurous compounds vented from Io's interior. The colors include the familiar yellow sulfur of Earth's volcanic areas, but because the color of sulfur and its compounds depends on temperature as well as composition, virtually every shade of red, orange, yellow, and brown is represented on Io's surface.

Furthermore, Io does *not* have one important kind of feature which we have come to expect on planets — craters. Billions of years ago, Io was surely as cratered as the other moons and planets, but the fall of ash and flow of sulfur lava could bury every trace of an Io crater in a million years at most.

Think of what you might expect if you were aboard a spacecraft that had just landed on Io. First the sky: Io keeps one side toward Jupiter, just as the Moon keeps one side toward Earth. This means that Jupiter must dominate the sky as seen from one side of Io, and always hangs in the same sector. From Io, Jupiter is enormous: it subtends an angle of about 20° — covering 1600 times as much of the ionian sky as the Moon does in our earthly sky.

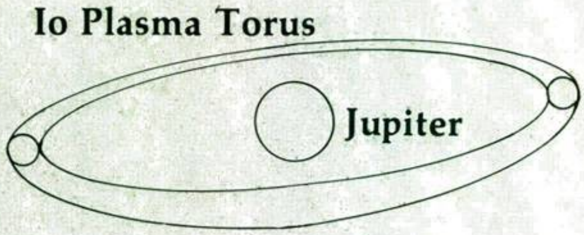
Io's day, that is, the interval from one sunrise to the next, is equal to its "year," or the period of revolution around Jupiter — about 42 hours. Each "day," the interval from sunrise to sunset, lasts about 21 hours. But because Jupiter covers such a large part of the sky, the Sun spends about 6% of each day, nearly 2½ hours, in total eclipse behind Jupiter.

Suppose we were to spend a whole "day" on Io. What would we see? Let's start in the morning, at some place where the Sun is behind the great mass of Jupiter in the sky, and Io's landscape is in darkness.

9 a.m., Local Io Time

The atmosphere of Jupiter is back-lit, and shows up as a dull-glowing, sunset-red ring in the sky. This,

The Io Torus



by David Morrison

Ringing Jupiter at the distance of Io is a donut-shaped volume, or torus, of plasma that originates from Io. Atoms escaping from Io's volcanos expand outward as a gas, but soon they are stripped of electrons and become electrically charged. Caught by the spinning magnetic field of Jupiter, they become part of the torus, circling Jupiter at 75 kilometers per second with the same 10-hour period as Jupiter itself.

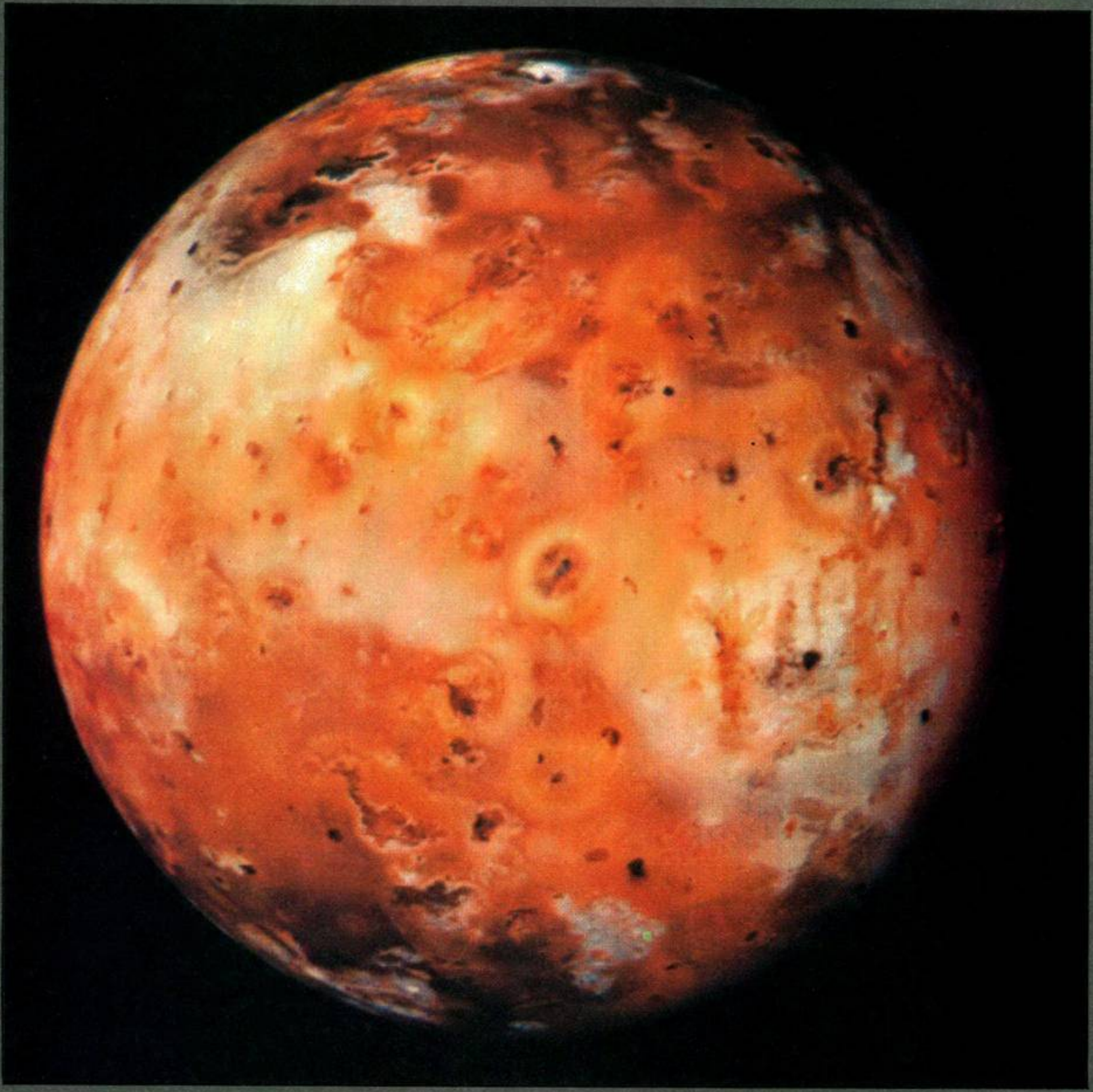
Even from a distance of 150 million kilometers, the Io torus was easily detected by the Voyager UV spectrometer. The strongest radiation comes from twice-ionized sulfur (atoms that have lost two electrons) (S-III), emitting at a wavelength of 69 nm, or about one-eighth the wavelength of visible light. The spectrometer also detected glows from atoms of triply-ionized sulfur (S-IV) and twice-ionized oxygen (O-III).

Scans across the torus showed it to be half-a-Jupiter-diameter thick, and three jovian diameters out. The torus is centered on the magnetic, rather than the rotational, equator of the planet, so it appears to wobble as Jupiter spins.

In order to produce the intense glow observed, the electron temperatures in the torus must be 100,000° K, with an electron density of about 1000 per cubic centimeter. The brightness in the ultraviolet corresponds to a radiated power of more than a trillion (10^{12}) watts. This enormous energy must be continuously supplied by the magnetosphere.

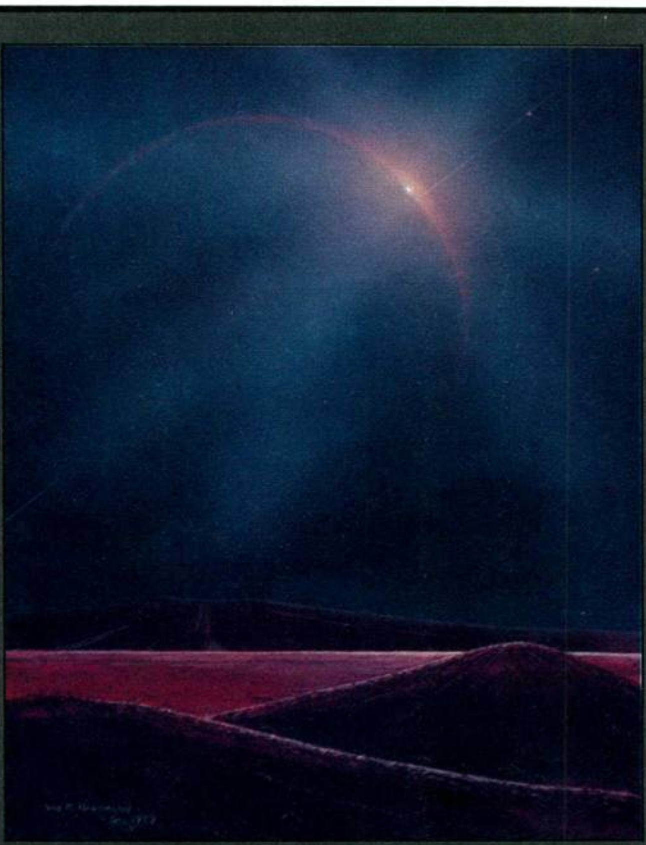
The ultraviolet emissions from the Io torus seen by Voyager differ from those seen in 1973 and 1974 with the UV instrument aboard Pioneers 10 and 11. The torus had grown by more than a factor of ten in brightness. As noted by the Voyager team, "Because of the remarkable differences...we conclude that the Jupiter-Io environment has changed significantly since December 1973. The observed differences are so spectacularly large that this conclusion does not depend on a detailed comparison of the two instruments, their calibrations, or the observing geometry."

The reasons for this change, or the degree to which it reflects a large-scale variation in the volcanic activity of Io, is one of the major questions arising from the Voyager mission.

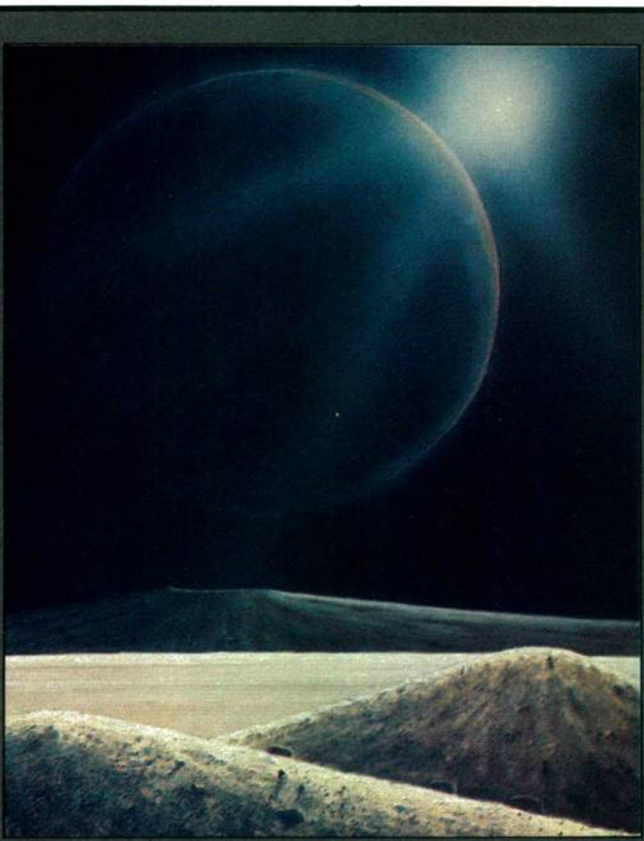


Vivid shades of orange, yellow, brown, and white — plus strange topographic features — mark the surface of Io. The equator, which runs horizontally across the picture, is generally lighter than the polar regions (top and bottom on this page). More than 100 small dark brown or black spots — volcanic calderas — dot the surface. Volcanic flows and ash deposits blanket the jovian satellite. In this view of the hemisphere that faces away from Jupiter, north is at top.

NASA/JPL photo.



The Sun is in eclipse behind the looming and ringed Jupiter, while the frosted landscape seems to glow in the dull ruddy light. This and subsequent paintings by William K. Hartmann.



The mid-morning sun heats the thin surface covering of sulfur-dioxide ice and evaporates it in a matter of minutes. Note the low profile of a volcano in the background.

in turn, illuminates the scene before us with a dull red glow. Because Io has negligible atmosphere (except for a bit of sulfur dioxide gas erupted and diffused from volcanos), the sky is space-black. On the ground is something we didn't see from orbit: a thin coating of snow or frost glistening in the faint light. With the light of the Sun cut off, the ground is cold, and something has frozen on it.

10:00 a.m., Local Io Time

Finally the eclipse ends. As the Sun emerges from behind Jupiter, it begins to warm the frigid landscape. The temperature "soars" toward 125K (-230° F). We suddenly realize that Io is manifesting yet another phenomenon: the "post-eclipse" brightening. In the mid-1960s, astronomers Alan Binder and Dale Cruikshank monitored the brightness of Io before and after its eclipses, hoping to discover whether Io had an atmosphere.

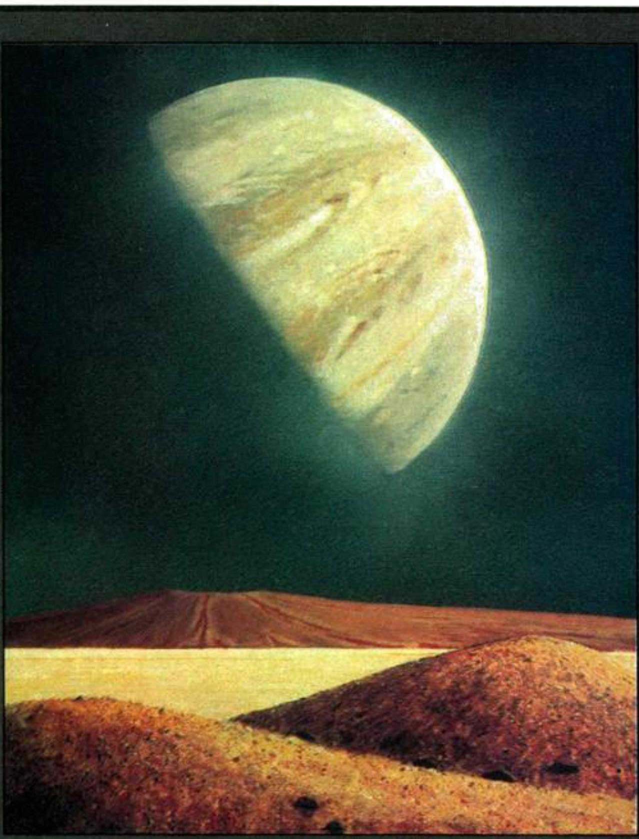
Sulfurous lavas scar the surface of Io with tangled patterns. NASA/JPL photo.

Their reasoning was that during the cold eclipse period, clouds, fog, or frost might condense and last for a few minutes after the eclipse, causing Io to be brighter than usual for those few minutes. Sure enough, they found that Io was often lighter than usual for 10 to 15 minutes after an eclipse. As other observers checked this result, it became clear that it did not happen after every eclipse — only sometimes. This shed doubt on the phenomenon, and when later data showed Io has virtually no atmosphere, the phenomenon was put on the back burner reserved for unresolved curiosities.

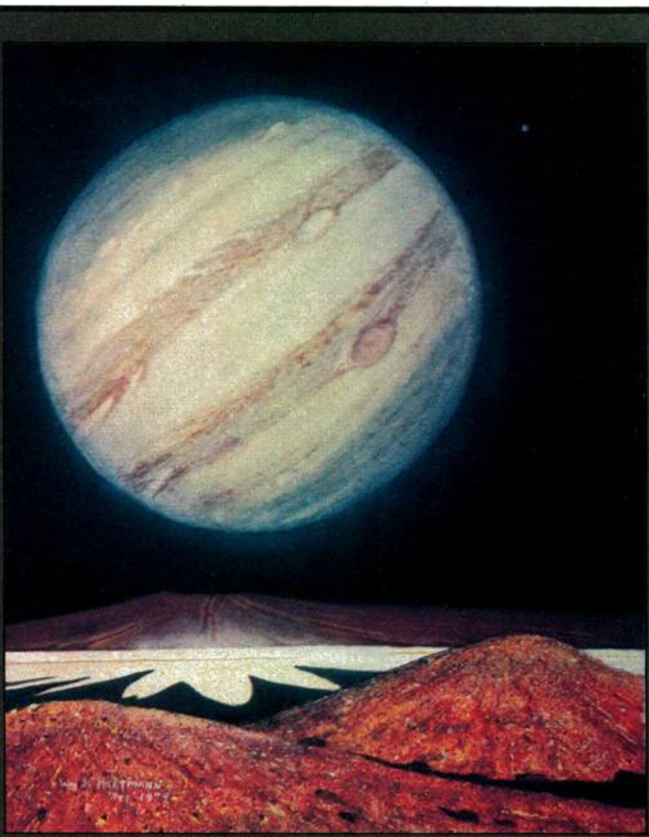
Voyager, however, may have provided an explanation. Among the volcanic materials erupted on Io is believed to be sulfur dioxide (SO_2) that can condense into a whitish frost or snow when the temperature drops. Calculations suggest that if several large volcanos happen to be erupting during an eclipse, enough sulfur dioxide might condense on the orange or red volcanic plain to brighten the overall appearance of Io. Thus, for just a few minutes after the eclipse ends, we see a light-colored SO_2 frost deposit covering the surface in front of us.

3:00 p.m., Local Io Time

Some 10½ Earth hours later, Io has moved a



Under the glare of the afternoon Sun, Io's vividly colored plains of volcanic rubble reach a peak temperature of -230° F. In the sky, the sodium torus shimmers with a yellow glow.



Jupiter fills the sky as shadows lengthen toward sunset. When night falls and the temperature plunges toward a low of -320° F, we wonder if there is enough sulfur dioxide atmosphere to freeze tonight.

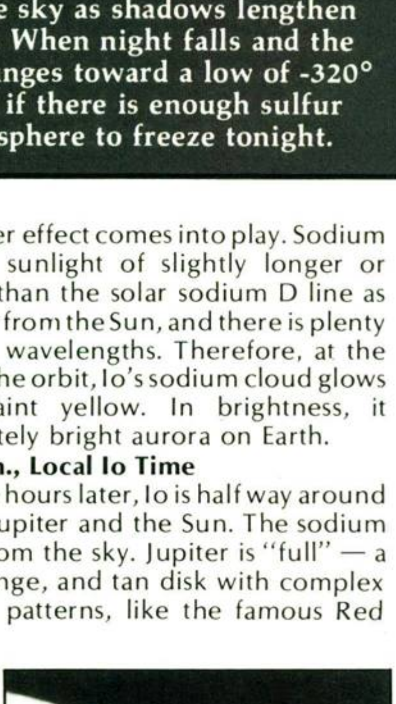
quarter of an orbit around Jupiter. The frost has long since burned off under the Sun, and the yellows and oranges of Io's normal surface are prominent. Jupiter is now lit from the side by the Sun, in the phase resembling Earth's "first quarter" moon. Then we notice another of Io's surprises: a faint yellowish glow in the sky, first discovered from Earth by Harvard/Arizona astronomer Robert Brown. A large, thin, gas cloud of sodium, sulfur, and other atoms surrounds Io. Io orbits inside the Van Allen radiation belts around Jupiter, and energetic atoms trapped in the belts strike Io's surface and knock atoms loose. Other atoms are spewed into space by Io's volcanic eruptions.

As they escape Io, these atoms diffuse out into a cloud many Io-diameters wide and stretching forward and backward along Io's orbit. Where sunlight strikes the atoms, it excites them, and they absorb energy momentarily, then re-emit it at the same wavelength. Sodium atoms, in particular, absorb and re-emit the yellow light of "sodium D."

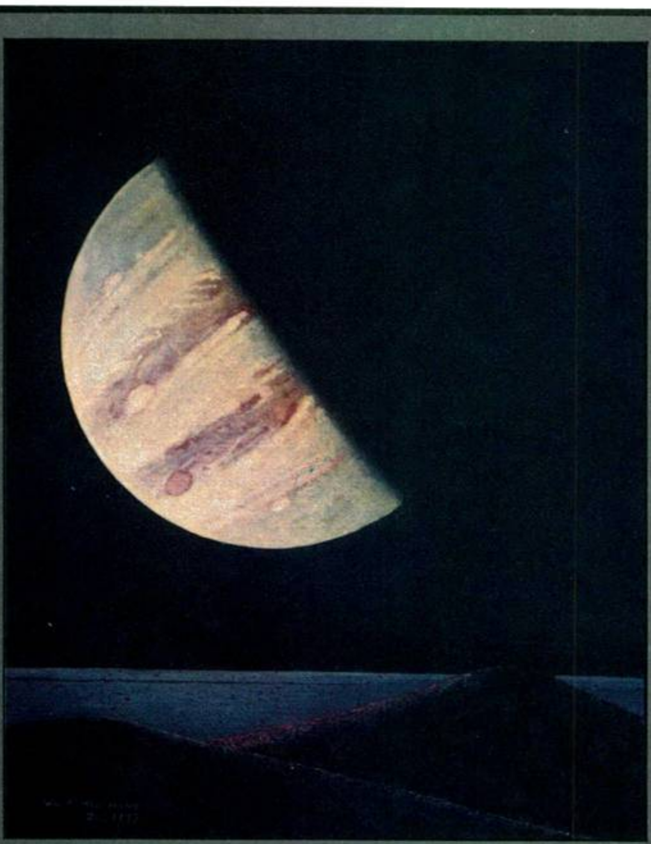
Now the physics gets complex: the Sun's atmosphere absorbs much of the sodium D light leaving the Sun, so that this wavelength is almost absent from the solar spectrum. We would expect that sodium atoms would not be excited, and therefore would not glow. However, when Io is moving toward or away from the Sun (as it is ¼ and ¾ of the way around the orbit from the "noon" position), the Doppler effect comes into play. Sodium atoms then absorb sunlight of slightly longer or shorter wavelength than the solar sodium D line as they move toward or from the Sun, and there is plenty of sunlight at those wavelengths. Therefore, at the quarter positions in the orbit, Io's sodium cloud glows an unmistakable faint yellow. In brightness, it resembles a moderately bright aurora on Earth.

9 p.m., Local Io Time

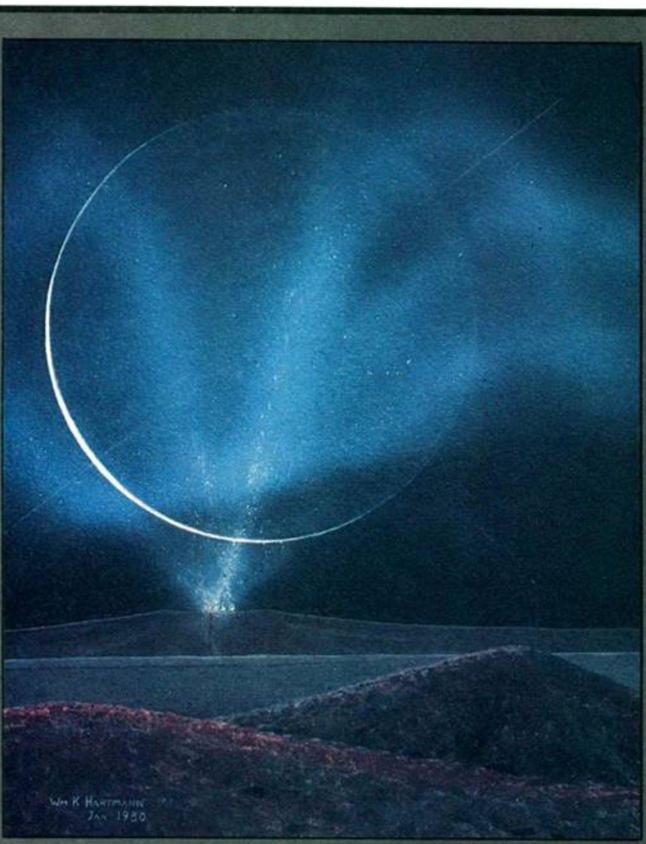
About 10½ Earth hours later, Io is half way around the orbit, between Jupiter and the Sun. The sodium glow is now gone from the sky. Jupiter is "full" — a dazzling yellow, orange, and tan disk with complex everchanging cloud patterns, like the famous Red



A graceful plume belies the violence of this volcanic eruption on Io. NASA/JPL photo.



The last quarter of Jupiter — illuminating the landscape more brilliantly than 200 last quarter moons on Earth — hangs in the night sky. Jupiter's glow drowns out all but a few bright stars.



Just before dawn a nearby volcano erupts, sending a plume of gas and ash high into the sky. How long the eruption will last we cannot say — but we briefly admire its beauty before taking cover.

Spot storm system.

By coincidence, the 10½-hour period needed for Io's quarter-trip around Jupiter is nearly equal to Jupiter's rotation period, so Jupiter displays the same cloud patterns again — except for the changes due to the weather systems on the massive planet. As we face Jupiter, the Sun is at our back, and the vivid landscape is illuminated by the low Sun as shadows stretch away from us toward the huge planet.

3 a.m., Local Io Time

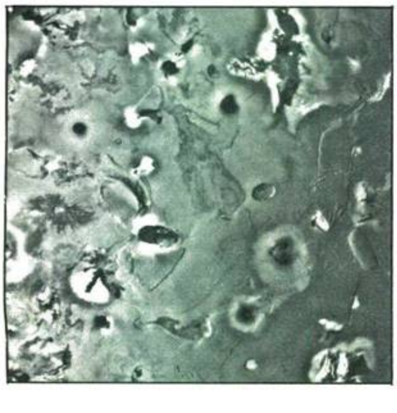
The Sun has set at our location. We have now traveled ¾ of the way around the orbit and Jupiter is in its "third quarter" phase. Again we see the yellow sodium glow in the sky, perhaps a bit brighter now — depending on the amount of volcanic gas emitted in the last few days. In the cold of night, some SO_2 frost may have formed again, but it's hard to see it because the landscape is illuminated only by the dull yellow light of Jupiter itself.

6 a.m., Local Io Time

Perhaps just before dawn, a nearby volcano erupts. Jupiter is a crescent in the sky. We gaze in awe as the volcanic plume shoots up from the darkened surface, where we are, and into the light of the Sun. How high is the plume? Maybe a hundred kilometers — perhaps two hundred. The delicate traceries of sulfurous ash and gas glow in the predawn sky, while the shadow of Io falls across the lower part of the plume.

So far no one has stood on the plains of Io to see the views or feel the ground tremble as the volcanos explode. But if we humans do manage to establish a viable planetary economy, if we don't blow ourselves up or imprison ourselves forever on a resource-exhausted planet, the day may come when, heavily shielded from Jupiter's radiation environment, humans will see the sights of Io — not through spacecraft instruments or paintings, but with their own eyes.

William K. Hartmann is a senior planetary scientist at the Planetary Science Institute in Tucson, Arizona.



Scarps, cliffs, uplifted blocks, and ashfall deposits mark the Io terrain. NASA/JPL photo

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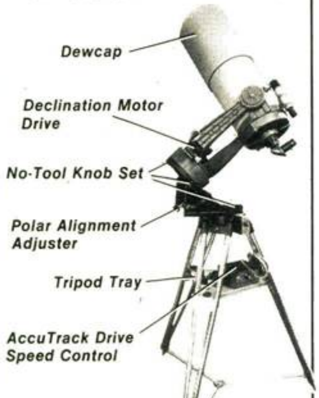

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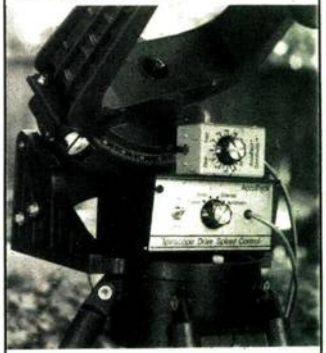

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Dr. Louis Friedman is the executive director of The Planetary Society, a publicly supported space interest group dedicated to showing popular support for a continuing program of planetary exploration, and for the search for extraterrestrial life.

ASTRO: Who is behind The Planetary Society?

LF: Carl Sagan is president of the Society, and Bruce Murray, the director of the Jet Propulsion Laboratory, is vice-president. I'm executive director. And Charlene Anderson is managing editor of the society's newsletter, *The Planetary Report*.

ASTRO: How much time can Sagan and Murray really expect to spend on The Planetary Society? They both have a few other commitments here and there!

LF: I'm very pleased with the amount of time and devotion they have for the society. They're both personally committed. This is no hobby for them; it's no side effort.

You're right, though, they can't come down to the office and handle the mail and work the phones. But they do read everything. We talk at least several times a week. And I've never had any problem of access, with the obvious exception of, say, when they're on a plane or in a foreign country. So they are very much directing this society.

ASTRO: Obviously The Planetary Society is on its way now: you have an office in Pasadena; you've started your membership drive. So how many members do you now have, and how much money?

LF: We have about 25,000 members now, but it's a dynamic situation, so I can't say exactly. We expect to have more than 50,000 members by the end of April 1981.

On the funds aspect, right now we're taking everything left over after the newsletter and plowing it right back into the membership drive. It's a very tight rope. We have no heavyweight financial backing that allows us a big bankroll.

ASTRO: How much for a membership in the society?

LF: It's $15, and much of that goes to the newsletter. We're also planning to sponsor a national lecture series, and talking about a festival of planetary information. It's all intended to help people get more out of the planetary program.

JPL/NASA

We also want to help revitalize certain research projects with "seed money" funding. SETI, for example, and asteroid mission planning. And, we'll be serving our member's needs as they arise, helping individuals find information, for example, and pictures.

But very importantly, we're spending money to grow, gathering a community of interest to show legislators that we are present and that we're interested in planetary exploration.

ASTRO: There have always been plenty of people interested in planetary exploration.

LF: The Planetary Society demonstrates that by its existence and its rapidly growing membership.

ASTRO: Tell me, Lou, what's the genesis of the society? Who sat down with whom and slung the bull at two in the morning over coffee? What made Louis Friedman throw up his hands and say, "That's it! I've had it! We've got to do something!"?

LF: Well, I'm not the one who first said, "Let's have a Planetary Society!" Bruce Murray and Carl Sagan were the ones who first said that, and then came to me.

Bruce and Carl have for many years talked about this to each other and to many of their colleagues.

Meanwhile, I was in Washington, DC working for then-Senator Stevenson's subcommittee on space. I helped set up space policy hearings and worked with people who were trying to make operational remote sensing from space a U.S. policy.

I was very impressed with the number of people outside the space community who were interested in space. Many were interested in space commercialization. Some were in the financial field, some in general business, some were just enthusiasts. But they were responsible people groping for a way to make space work.

All this set me to thinking: "Why can't we get the same thing happening in exploration?" I was looking for a way to bring in a larger group of people.

You see, based on my Washington experience, I was beginning to think there weren't going to be any more big planetary explorations. And by "big," I *really* mean medium-sized projects, orbiters, for example — not landers and sample returns.

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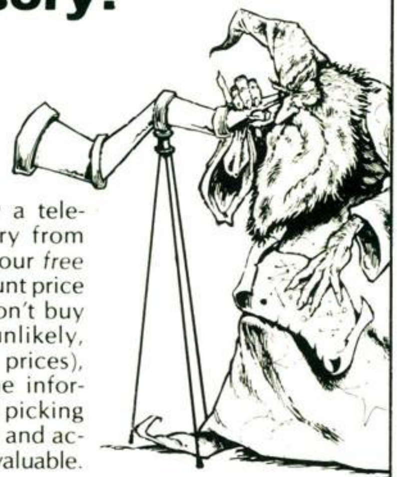

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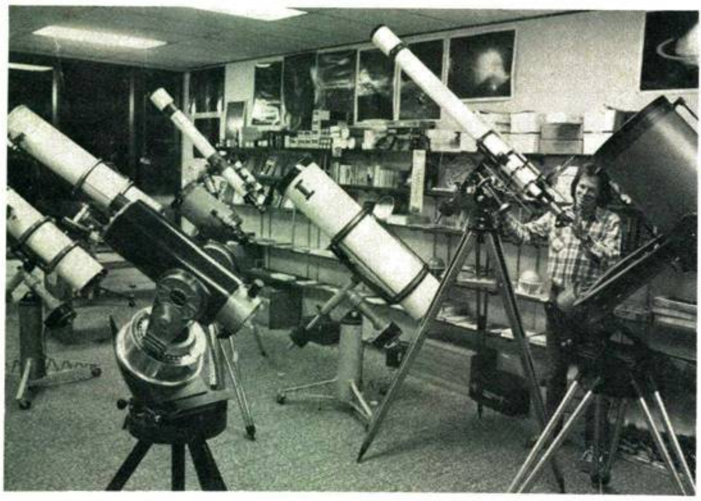

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about 800 scientists interested in planetary exploration, you simply can't justify a billion dollars for a good exploratory mission. Of course, that's not the real justification: what we're really doing is exploring new planets, new worlds.

Now *that's* perfectly justifiable — in fact, it's mandatory! But we in the U.S. don't see our planetary programs that way — we sell them on the basis of pure science....

So I was trying to get out of that box, and say, "We need a larger involvement."

Well, I came back to JPL from Washington from time to time, and on one of these visits I started talking with Bruce Murray about it. And he interrupted me and said, "Yeah, that's all well and good, Louis. Listen, I want to talk about something Carl and I have been discussing. We need a...."

And all of a sudden, in my mind it clicks. This is exactly what's needed. We need to bring together all the people who are already interested in space exploration. Just as we have an environmental movement, we need a space movement.

ASTRO: So you feel the "space constituency," if you will, the people who are "for" unmanned planetary exploration already exists out there in America.

LF: Oh, yes. And it's interesting that a lot of people in Washington don't realize that, even though they support it. Even some politicians we might consider anti-space exploration think they're in front of their constituency by giving space minimal support.

I remember one congressman whom I never regarded as particularly pro-space, saying: "My God, if my people ever knew I was supporting a five billion dollar space program, they'd throw me out of office. It's only because I'm so smart and have so much foresight that I do it and don't tell them." Well, he thinks he's right.

We think he's wrong: even though we don't have to convince him of the importance or the virtues of the space program, we have to prove to him that his constituency likes space, too. And a public interest group like The Planetary Society can do it.

ASTRO: Who else besides you, Bruce, and Carl were in on the beginning of The Planetary Society?

LF: A lot of people. Young scientists committed to exploring new worlds are devoting extra time and effort to the society, writing and speaking. They've helped.

So have people outside the scientific arena. They also see space as one of the best enterprises of our government. John Gardner, the founder of Common Cause, is very interested. I met and talked with him several times while we were setting up the society, getting his advice.

And of course former Senator Stevenson and Senator Harrison Schmitt were very helpful, telling us, "Here are some people you should talk to; here's what you might do and think about." For example, James Michener, the author, spent four or five days discussing this with us.

ASTRO: What reactions, if any, did you have from NASA?

LF: We didn't talk to NASA at all. They're the agency carrying out the government's program. They could not get involved with us, and we don't want to get involved with them. We don't want NASA support; we don't want to put them or us in some uncomfortable position.

ASTRO: What was your reaction when you first heard about President Reagan's cuts in the NASA budget?

LF: Extreme concern, because the initial rumor was that the planetary program would be entirely wiped out. I don't think the Reagan people were aware of this, and when it was pointed out to them, they backtracked some.

ASTRO: How do you feel now that the Galileo mission has apparently been restored?

LF: I hope that it represents some commitment to a continued U.S. planetary program; however, I don't think it *is* a commitment, and I don't think it is enough to continue or restore the planetary program.

ASTRO: What would be?

LF: The single important and practical commitment would be to initiate a Halley's Comet mission. No other single act would be so doable, so cost effective, and so symbolic of our space program's vitality as the Halley mission.

ASTRO: What concerns you most about the budget cuts?

LF: We know nothing about their policies and priorities — only that they want to cut the budget. If they are using the budget to establish policy, then I'm alarmed. But if they don't realize the effects of the cuts, then at least I hope that they will be responsive to changing the particular cuts so that planetary exploration can continue.

ASTRO: What policies could harm the planetary program?

LF: Planetary exploration could become the victim of a growing militarization of space. We might end up with our civilian space program put aside for the military. I worry about that.

Or we could be the victim of the general attitude of, "Let's cut out all the discretionary things in the budget, regardless." And certainly the space exploration program is a discretionary item.

However, I'm optimistic. I think they'll be responsive to our message.

ASTRO: Would you consider offering President Reagan a charter membership in The Planetary Society?

LF: (grins) I'd be delighted to! Even a complimentary membership! And many of his colleagues in the entertainment and business worlds are very interested in this. So it wouldn't be out of character for him to accept.

Joel Davis
Olympia, WA

Ed. note: For membership and other information write: The Planetary Society, P.O. Box 3599, Pasadena, CA 91103.

Drazen Premate: Space Champion

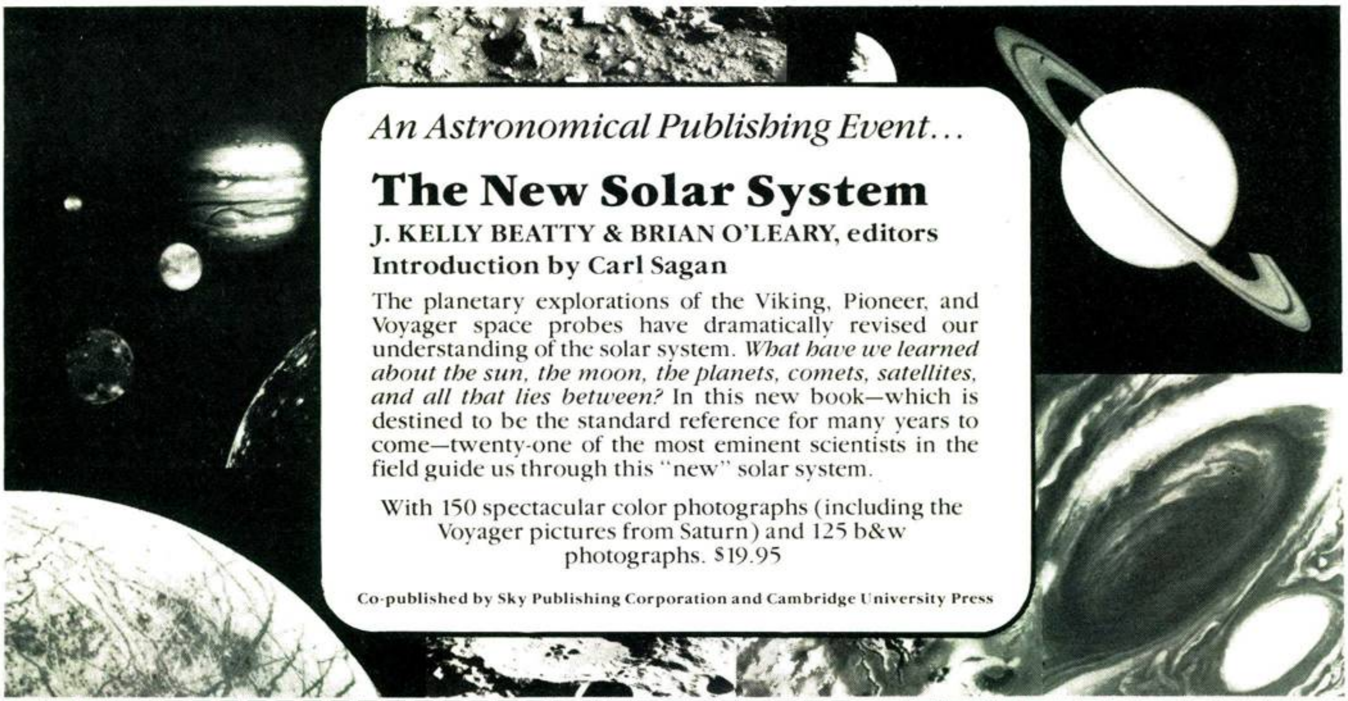
Drazen Premate, a research associate in the Department of Physics and Space Sciences at the Florida Institute of Technology (FIT) in Melbourne, is executive director of the newly-formed International Space Research Society — Inter-Space. He is currently designing a payload reserved by FIT for NASA's Get-Away Special (GAS) program aboard the Space Shuttle. Premate, 25, Yugoslavian born, is currently writing a book on the GAS program from his perspective as a former graduate student and European. He has lived in America since he was 17.

ASTRO: There are all kinds of societies today involved with space exploration and research. Where does the Inter-Space Society fit in?

DP: Our main goal is to unify those young people around the world whose interests lie in the field of near future space exploration and research. NASA's GAS program is a baseline in our objectives. While I have nothing against all these space colonies, solar powered satellites and so on — in fact it's great that they might someday exist — I'm interested in the present. Unfortunately, the times are very tough. Funds are being cut, so it could be ten, twenty, or thirty years before any of these projects are realized. The youngsters who are so eager to do something now will be retirees before they see results.

ASTRO: So Inter-Space will provide an outlet for the restlessness of youth?

DP: Yes. Quite a few students,



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young professionals, and space enthusiasts are eager to create something now that could be put into orbit and yield results in maybe three years. The technology is there. It's only when you reach the point of designing an experiment you realize how many unknowns there are in dealing with anything that has to fly. I think there's a need for channels through which we can get information — such as how to put payloads together, obtain parts, equipment, and funds.

ASTRO: How will Inter-Space do this?

DP: Our first step will be a monthly newsletter and a quarterly journal. The newsletter, *Info-Space*, covers Shuttle activities at the Kennedy Space Center and developments all around the world affecting those interested in space research. Our first issue was printed in March.

The journal, called *START* (Space Technology And Research Transactions), will have papers and articles on projects in the GAS program and other low-cost projects undertaken by NASA or aerospace companies.

So many young people are overwhelmed by the feeling that *everything* has already been researched. But sometimes the very lack of advanced theory is a plus in discovering new things. Often, even when students have had good ideas, they have been afraid to go to their professors or bosses with them for fear of ridicule, or of finding it's already been tried.

We'd like to hear from students working on payloads now, as well as others with information on any aspect of space research in their local areas.

ASTRO: And later you'll get into actually funding some payloads?

DP: Yes. If someone has a good idea but no funds, the society can look into ways in which the project might be realized — finding a company sponsor, for example. Or if we know of a company that is looking to test a device, say a new microprocessor, it may want to donate it so the results of how it performed in space would be known before the company put it in some large project.

We will have an advisory committee to consult on the selection of future projects. We are very well aware that the amount of money we'd have available would be nowhere close to the needs that exist out there. Even though GAS reservations on the Shuttle are relatively inexpensive — they start at $6,000 — the complete development of a GAS payload will be $20,000 to $30,000.

ASTRO: Except for yourself, are the other Inter-Space board members all students?

DP: No, of the five, four are students, and one, Tony Boatright, is an FIT graduate now working at Kennedy Space Center. All of the members, however, have been involved in local groups before. Our executive vice-president, Martin Davis, for instance, is president of the local L-5 Society.

ASTRO: What are some of your other goals?

DP: In the future we hope to become a final clearing center for GAS programs — a lab where special experiments can be performed, and GAS users can finalize their payloads, particularly the biological experiments. These are very hard to keep up because NASA requires them about a month before launch time, and that's way too long for biological experiments. Our group, in cooperation with NASA, may be able to cut down the requirement time to maybe two weeks before launch.

Another of our goals is to create branches of Inter-Space in other parts of the U.S. as well as abroad.

ASTRO: Since you want to stay in close contact with *GAS-line*, the newsletter distributed among those working on reserved GAS payloads, does this mean that your membership will evolve toward an elite group of high achievers involved in a GAS project?

Photo by A.J. Matyas

DP: Not at all. In fact, most of the people who would like to join us will probably not be directly involved in the GAS program. Our membership is open to anyone who's interested in research in space. In fact, the best criticism of GAS experiments may come from these people. The newsletter will be written in layman's language — all terms will be explained and no jargon or acronyms will be used. I think it's crucial to keep the language very simple and precise.

ASTRO: You must share a common interest, then, with the efforts of Carl Sagan's PBS *Cosmos* program to bring science into everyday language.

DP: I think what he's doing is wonderful. And I don't think it's right that he's been criticized by some of his colleagues, because all of us must understand that the *only* way we'll be able to show the benefits of space science is by presenting it in layman's language.

If you mention physics, astronomy or orbital mechanics, people ordinarily shudder and turn away because they associate these with equations, difficult concepts, years of hard work and all that.... Science, I think, needs all the showmen it can get.

ASTRO: From what you've seen over here so far, where do you see the space program heading?

DP: Once the Shuttle gets going, I don't think we'll see a repeat of the slowdown we've seen these last few years.

I think it's particularly important to get young people interested in space. Today there seems to be less and less enthusiasm among young people to do any kind of constructive work. I'm afraid people may become just passive users of technological gadgets, instead of using the technology to create things.

One reason, I think, is the lack of incentives for youth. It always seems like students have to wait years before they get a chance to do some real research work — instead, it should be a very challenging part of their lives.

ASTRO: Do you think Inter-Space will benefit its members?

DP: Yes. They'll be better prepared to go to work for some of the companies when they get out. Everyone who gets involved in payloads gets a very broad background in all the related fields, so they can get positions where they can work with top management that is coordinating a whole big project, not just a specific little part that some engineers may be doing.

By the way, letters or papers should be sent to Inter-Space Society, P.O. Box 338, Melbourne, FL 32901. A year's membership in the Inter-Space Society costs $10.00. (Please do *not* send a check, but write for a membership application kit which includes a survey sheet for your special interests and skills. Membership includes a subscription to the newsletter, journal, and a T-shirt.)

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mercury emerging: a special sight in the may sky

by
Fred Schaaf

the wanderers

Many skygazers have never seen two of the six naked-eye planets. One of them is faint enough to require dark country skies and a knowledge of exactly where to look. But the other is always fairly bright and sometimes easily outshines even Sirius, the brightest star. How then could such a planet be missed?

The bright planet in question is **Mercury**, and it's not frequently seen because it spends so much of its time very close to the Sun in our sky. Mercury, of course, is the innermost planet, about three times closer to the Sun than we are — it's also the fastest planet and the smallest, except for strange Pluto. The hummingbird of the planets, Mercury flits and hovers around the Sun-flower. That Sun is so bright we can seldom observe Mercury well, but this month we will have a good opportunity.

It's only when the Sun-Mercury-Earth angle is just right that Mercury emerges slightly to one side or the other of the solar glare (either after sunset or in the predawn sky). When the Sun and Mercury appear farthest apart from our point of view, Mercury is said to be at its "greatest elongation," and we are fortunate to have a fairly good example of this on May 27.

On that date, Mercury is at about its average distance from the Sun in its orbit, so the elongation in our sky reaches roughly 23°. What is really important, however, is the planet's altitude above the horizon at sunset, and that depends not only on its separation from the Sun, but also on how steep an angle the ecliptic makes with the horizon at that time and place.

For example, *if the 23°* separation between the Sun and Mercury were parallel to the horizon as they set, Mercury would obviously go down at the same time as the Sun. And if the elongation were perpendicular to the horizon, then the planet would be the full 23° directly above the Sun and set much later. For observers in the U.S. this month, the angle of the ecliptic falls between these extremes and is fairly steep, so this particular greatest elongation is rather good (much as in January-February), and we should be able to glimpse the planet for about two weeks before May 27, and perhaps almost as long after.

Around that date, Mercury will be setting at the very end of astronomical twilight — about two full hours after the Sun — and will shine at +0.6. On May 3, it is a blazing -1.5 when it passes just over a degree north of Venus, but the two are then still too near the Sun. On the 16th, ambitious observers with clear skies and good binoculars might spot the 5.6 magnitude star 98 Tauri just a few minutes of arc north of Mercury.

The other planet seldom seen with the naked eye is the very faint **Uranus**, but it's at its best this month. William Herschel discovered the seventh planet with a 6-inch telescope in 1781 — exactly 200 years ago. It comes to opposition on May 19, shining at its maxiumum brightness of 5.8 all month, and may be spotted with unaided vision on dark, clear nights in skies that have little light pollution.

Uranus is still in Libra, but it's now approaching the prominent line of stars which forms the head or front of Scorpius. All this month, Uranus is well within a degree to the east of the 4.7 magnitude Kappa (κ) Librae and cannot be mistaken for any naked-eye star in that location. If you can observe in dark skies this month, you will have a chance to see the most distant world visible to the naked eye. Uranus is at its closest this month, just 2,663,000,000 kilometers away!

Only four days after Uranus is closest to Earth, **Mars** is farthest from us — and, remarkably, the apparent size of the two in a telescope is almost precisely the same, about 3.85 seconds of arc.

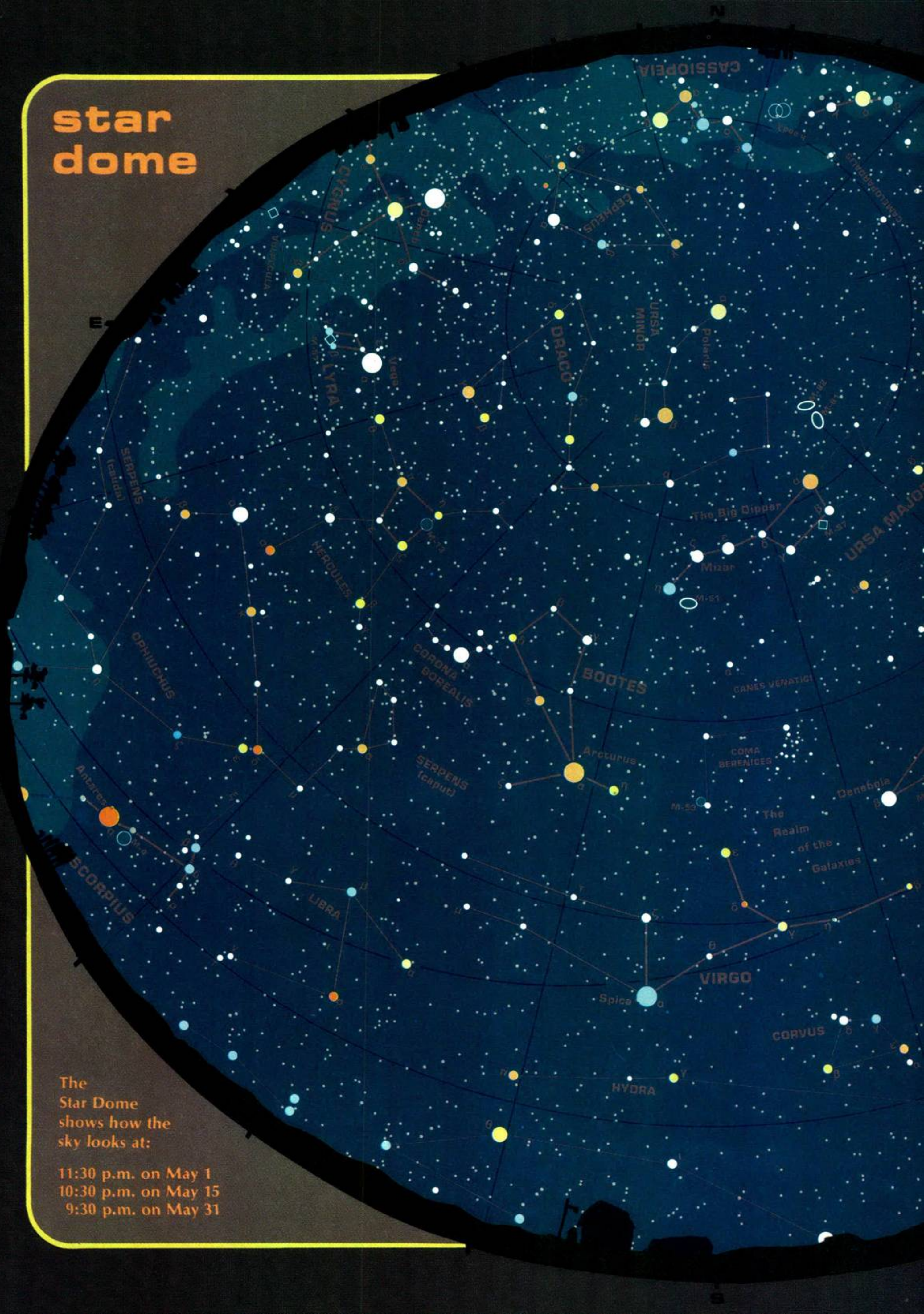
Mars is still unobservable in May, but the other planet which had a conjunction with the Sun in early April will be coming back into fairly prominent view. Although **Venus** sets only about 30 minutes after the Sun on May 1, that figure increases to over a full hour by month's end. On what evening can you first spot Venus, low in the west, beginning its apparition as the Evening Star? On May 20, Venus is 6° north of Aldebaran, and early next month the planet will have an observable conjunction with Mercury.

Last but certainly not the least of our planets this month, are **Jupiter** and **Saturn**. The two giants are riding at their highest in the south as night falls and are still no more than 3° apart, with Jupiter still easily more than Sirius-bright and Saturn still outshining the fairly nearby Spica. The dim star near Saturn at month's start is Eta (η) Virginis, but the planet moves on a bit during the month, slowing as it approaches the end of its retrograde motion for 1981. Jupiter ceases its retrograde motion on May 28, and on that date it is also, for the first time in 12 years, at its greatest latitude north of the ecliptic — the point in its orbit which is farthest above (or north) of Earth's orbit. After that date, the separation between Jupiter and Saturn will again dwindle as they approach their last meeting in the Great Conjunction.

Several other interesting events

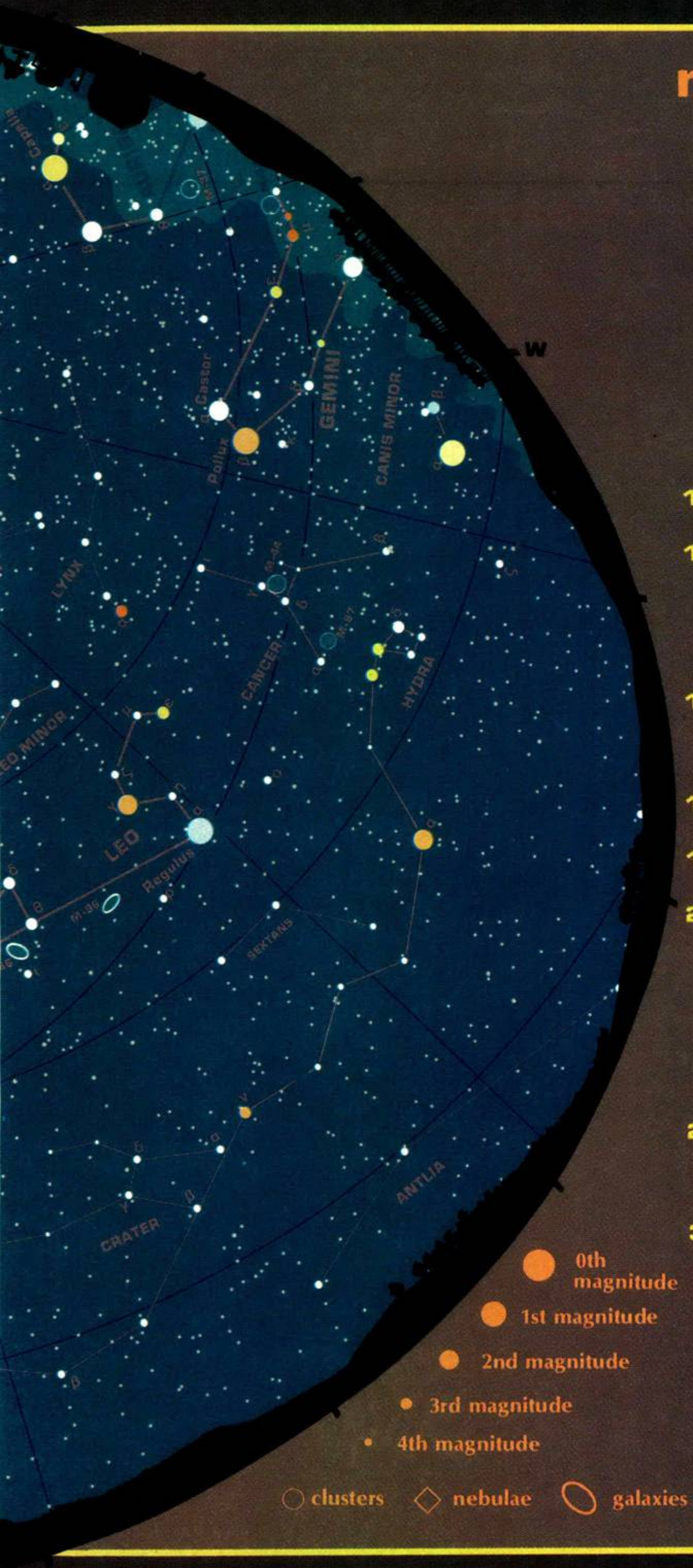
You don't need a giant telescope to start seeing the wonders of the sky. Even a basic 3-inch reflector can produce an excellent view like this one — of the Moon's southern highlands and the bright rays from Tycho crater (top) — taken by John Shibley. Below: *100x will clearly* reveal Jupiter's dark belts and light zones. Photo by Dave Meyer.

star dome


N
E
S
CASSIOPEIA
CYGNUS
Deneb
CEPHEUS
CAMELOPARDALIS
VULPECULA
URSA MINOR
Polaris
DRACO
LYRA
Vega
SERPENS (cauda)
HERCULES
M-13
M-81
M-82
The Big Dipper
M-97
URSA MAJOR
Mizar
M-51
OPHIUCHUS
CORONA BOREALIS
BOOTES
CANES VENATICI
COMA BERENICES
Arcturus
SERPENS (caput)
Antares
SCORPIUS
M-53
The Realm of the Galaxies
Denebola
LIBRA
VIRGO
Spica
CORVUS
HYDRA

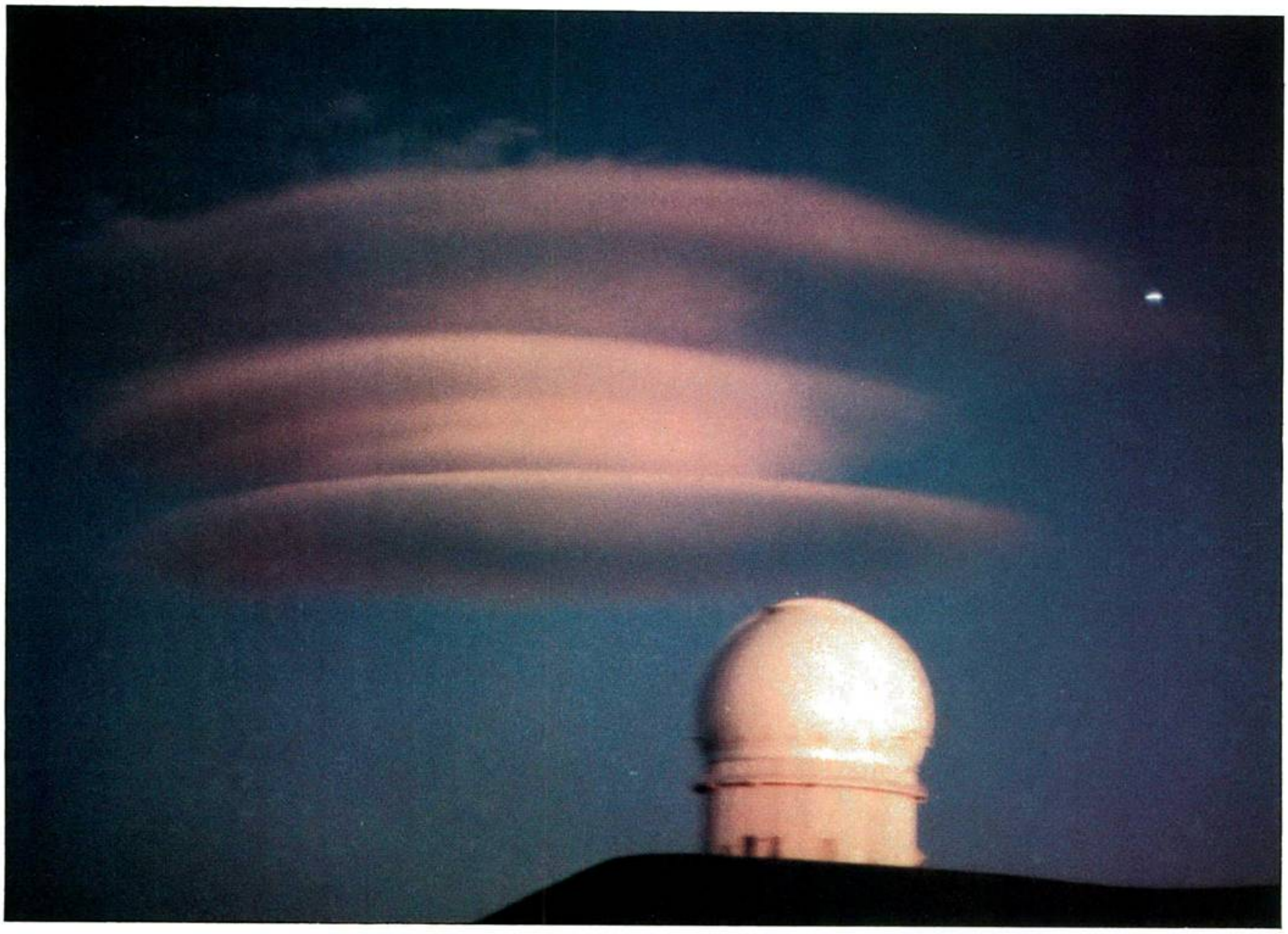
The Star Dome shows how the sky looks at:

11:30 p.m. on May 1
10:30 p.m. on May 15
9:30 p.m. on May 31


W
Capella
Castor
Pollux
GEMINI
CANIS MINOR
LYNX
M-44
M-67
CANCER
HYDRA
LEO MINOR
LEO
Regulus
M-96
SEXTANS
CRATER
ANTLIA
0th magnitude
1st magnitude
2nd magnitude
3rd magnitude
4th magnitude
clusters
nebulae
galaxies

may sky almanac

3rd	Eta Aquarid meteors appear late tonight and early tomorrow morning. Expect to see 10 to 20 per hour (peak activity) coming from the central part of the constellation Aquarius.
4th	The Moon will be New at 12:19 a.m. EDT — practically the same time it's at perigee: 221,846 miles.
10th	First Quarter Moon at 6:22 p.m. EDT.
13th	At about 11 p.m. tonight EDT, the Moon will pass 3° north of Jupiter. Six hours later — at 5 a.m. on the 14th — it will overtake Saturn, passing less than 2° north of the planet.
15th	Between tonight and the 31st, Mercury will be at least 9° above the western horizon, 45 minutes after sunset.
17th	The Moon is at apogee this afternoon: 252,521 miles.
18th	Full Moon at 8:04 p.m. EDT. Also, Uranus at opposition.
23rd	Each evening between tonight and the 25th, Mercury is at its highest in the evening sky. Forty-five minutes after sundown, it will be about 11° above the horizon in the west-northwest (11° is about the width of a paperback book held at arm's length).
26th	Last Quarter Moon at 5 p.m. EDT. Also, Mercury will be at greatest eastern elongation at midnight EDT tonight.
31st	This evening, shortly after sunset, sharp-eyed observers may catch sight of Venus very low in the west-northwest.



Anyone who keeps an eye on the sky has a good chance to see strange and wonderful sights: this "stack of plates" over the summit of Mauna Kea is a lenticular cloud. It formed when smoothly flowing layers of air rose over the peak and condensed into flat sheets of cloud. At right is the star Sirius. Photo by Charles Kaminski.

involving solar system bodies occur this month. In the predawn hours from May 3 to May 5, the **Eta Aquarid** meteors (derived from Halley's Comet) are at their best, streaming from the southern sky at rates of maybe one to two dozen per hour in

The **Moon** will cooperate by presenting only a slim crescent less than one day old about 7° above the western horizon at sunset on May 4. On May 13-14, a gibbous Moon spends the night passing by Jupiter and Saturn.

the starry sky

The heart of the spring constellations is now overhead as darkness falls. That heart is a black pool of space in which float the beautiful irregular star cluster of **Coma Berenices** (Berenice's hair) and, beyond sight of the naked eye, crowds of galaxies sprinkled as carefree and generously as the small wayside flowers of May.

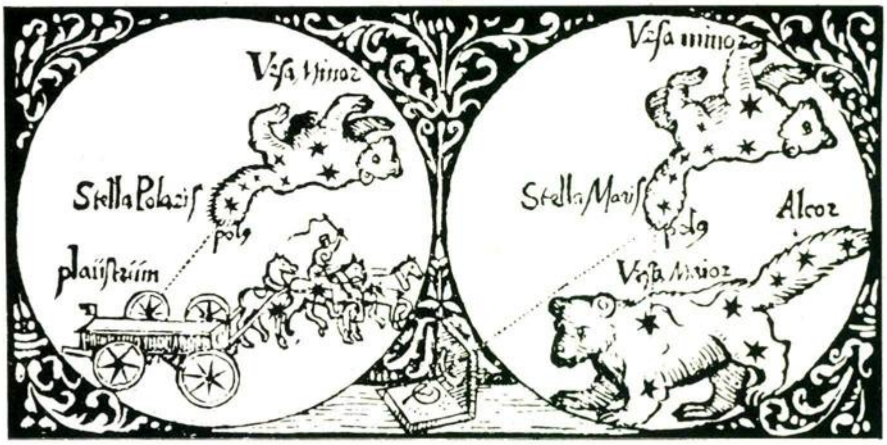
When we look high in the south at a point near the Coma cluster, we are staring straight up from the plane of our Milky Way Galaxy — as if we were looking out of a skylight. (There is also a lower "window" which shows us the region of the south galactic pole in autumn.) If this is a skylight, then our house is the whole Milky Way and the "sky" we are looking out to is the greater universe. We can see the distant galaxies and clusters of galaxies in that realm only with a telescope, or with the eyes of the imagination. But there are many fine stars surrounding the "skylight," marking the shores of this small circular sea of darkness.

High in the north, curves the handle of the **Big Dipper**, as its constellation **Ursa Major** slowly descends toward the northwest. The Pointers on the outside of the bowl direct us to **Polaris**, which forms the end of the **Little Dipper**'s handle, or the tail of **Ursa Minor**. And the Big Dipper's handle forms an arc which sends us to the brightest star of spring, mighty **Arcturus**.

Arcturus is just barely the second brightest star visible from 40° N. latitude. Only **Sirius**, now disappearing into the solar glare, shines brighter. Perhaps no bright star in all the heavens has more distinctive and unusual qualities than Arcturus. Its color is very prominent, and, to the careful observer, "orange" is only an approximation of its subtle hue (what would you call it?). The absence of fairly bright stars in the general area enhances the prominence of Arcturus — especially the dark realm roughly centered on Coma.

The reason this region is so sparsely starred is related to the most interesting of all facts about Arcturus. In next month's Skylore we will look at legends concerning this -0.1 magnitude luminary and consider the facts which make Arcturus truly a "gypsy star."

The kite-shaped form of **Bootes** the herdsman is dominated by Arcturus and is itself far more eyecatching than the few little stars under the Big Dipper's handle which form Bootes' pets, **Canes Venatici** (the hunting dogs). Across the Coma sea from Arcturus is second magnitude **Denebola**, which marks the east end of **Leo** (the lion). The Lion is declining to the west at this time, but remains prominent with its first magnitude luminary **Regulus**. Farther west in the Zodiac are **Cancer** (the crab), featuring the **Beehive** star cluster, and, now getting low, **Gemini** (the twins). The twin stars **Pollux** and **Castor** are very



conspicuous at this time of year, hanging together just above the fading fires of twilight.

The Lion borders Coma Berenices on the west, and to the south of Coma is another vast constellation of the Zodiac, **Virgo**, the virgin. Virgo is always portrayed reclining and holding an ear of wheat at her hip — "ear of wheat" is a literal translation of **Spica**, the name of the bright star which marks this position. Among first magnitude stars, only Regulus is closer to the ecliptic and a better target for the Moon and planets than Spica. This year, of course, the large, mostly dim shape of Virgo is brightened by lustrous Jupiter and Saturn, which are like jewels pendant from her neck.

Well below the current position of Jupiter and Saturn is a pair of constellations, quadrangle **Corvus** (the crow) and faint **Crater** (the cup), riding the wriggle of **Hydra** (the sea serpent). Just east of Virgo on the Zodiac is rising **Libra** (the scales).

To the east of Bootes' shoulders appears the pretty semicircle of **Corona Borealis** (the northern crown), and below it is the ascending **Hercules**. Not far above the northeastern horizon are **Vega** and **Deneb** — brilliant stars whose late evening appearance tells us that summer is on the way.

skylore

Last month we saw that numerous cultures around the world, many apparently isolated from one another, pictured the stars of our Ursa Major as a bear. In many cultures our ridiculously long tail on the celestial bear had to be explained, and the pattern of these stars (or at least those in the Big Dipper) looks far less like a Bear than a *Bier* or a Wagon. Did the myth of these stars as a bear start in one place and actually spread over the entire world, including pre-Columbian America? Let us examine some of the Western Hemisphere legends about these stories and see if we can throw any light on this question.

Among the North American Indians, the stars of Ursa Major certainly were identified as a bear. The testimony of various early explorers leaves no doubt that this idea was original with the native Americans — not derived from the traditions of the European newcomers. And in most of the American Indian stories, only the bowl of our Big Dipper is the Bear — the preposterous long tail of our Great Bear was pictured by them as other things, often hunters.

Some versions had the tail or Big Dipper handle as three hunters, and some as a hunter with two dogs. But in both cases the middle star, Mizar, was a hunter carrying a pot in which to cook the bear, and that pot was Mizar's famous companion star Alcor (visible to normal eyesight on any good night).

A richer legend tells of hunters who were birds pursuing the four-star bruin. In this account, our three tail-stars were (working out) Robin (Alioth), Chickadee (Mizar) and Moose Bird (Alcaid), and they were joined in this adventure by other hunters in a continuation of this arc down the side of our constellation Bootes: Pigeon (Seginus), Blue Jay (Izar), Owl (Arcturus) and Saw-whet Owl (Muphrid).

The story tells that Bear hibernated in his den (possibly Corona Borealis) during the winter. (These stars were low or hidden along the northern horizon in early evening at this time of year.) In spring, the great beast was seen rising ever higher in the northeast, trailed by the curving and slightly scattered line of hunters. By autumn, the lattermost hunters at last tired and dropped out of the pursuit (setting in the west) until only the first three were left. But Bear also had become weary, so finally Robin, who was ever closest in the chase, released an arrow which struck and wounded the beast. The giant creature's blood splashed on Robin's breast, giving him his badge of color, and spattered so far it tinged all the October foliage of the northern woods as Bear slipped from the sky. The Moose Bird (the Canada or Gray Jay) only then approached, demanding his share of meat, so that he was called "He-who-comes-in-at-the-last-moment." But the spirit of Bear occupied a new body which slept and then, as before, rose in spring so that the hunt began all over again, continuing the eternal cycle.

A complex and beautiful legend of the Blackfoot Indian tribe tells that the seven bright stars and Alcor were brothers and sisters (Alcor the youngest girl) who were pursued by an evil bear on Earth, but escaped to the sky. Farther south, the Aztecs saw these stars as the god Tezcatlipoca, who was punished in many ways, and finally forced to dance on his hands around the north pole of the sky.

It is apparently true that most North American Indians pictured a bruin in our Ursa Major, but did not consider Alioth, Mizar and Alcaid as a tail. One exception seems to be the Iroquois who, we are told, pictured a long-tailed Sky Bear here, and claimed that this was the normal, original form of all bears. It was vain Earth Bear who used to show off by fishing with his tail in a hole in the ice, until one very cold day the tail froze and fell off, leaving a stump. But perhaps this is one case in which the story was influenced by European beliefs.

There are Old World theories about how the Bear got his long tail, but the most famous myth about Ursa Major — the Greek one of Callisto and Arcas — does not try to account for it. Considering the various legends we have looked at here and last month, it does seem most likely that the idea of a bear spread through parts of the Old World by some linguistic confusion, but the American Indian Bear was probably a separate — and quite reasonably short-tailed — invention.

But the case is not closed, nor the mystery resolved. We have examined only a small selection of the vast wealth of lore, and it may well be that too much has been forgotten or confused ever to reconstruct the whole truth. Even the Lesser Bear, whose history is far less rich and (as Bear) far more recent, is shrouded in mystery. But how strange and enjoyable it is that two assortments of once unconnected stars have, through countless minds and sometimes mispronouncing voices, emerged to be ursine companions, even sharing some highly imaginative tales (and tails).

The two Bears are tail to head and head to tail. The Lesser Bear has a tail-to-body ratio which is even more unlikely than that of his big friend. In some future column we will explore Ursa Minor's invention (from dragon's wings), his reputed inventor (the first scientist to predict eclipses, and who fell into a well while watching the stars), and his relation to such strange things as the pear-shaped Earth that Christopher Columbus believed in.

ASTRONOMY
IN FOCUS

The Halley Fund

Sir / Delta-Vee, a non-profit space organization, has established a fund to push for a U.S. mission to Halley's comet. Our primary goal is to show the extent of public support for such a mission. Funds will also help NASA pay for some portion of U.S. efforts to explore Halley's comet.

The Halley Fund is similar to the Viking Fund, also operated by Delta-Vee, which this year will pay for the reception of data from the Viking lander on Mars during July and August. This will free funds to allow NASA to make an albedo map of Mars and analyze a two-year backlog of martian weather data.

While the Viking Fund has had continued success, we must also generate support for new exploration of the solar system. A Halley mission is both immediate and important, and it symbolizes the future of American space exploration. We hope the Halley Fund will spur Congress to add funds to NASA's budget so work can begin on a Halley flyby spacecraft. We plan a series of direct mailings and advertisements to peak in late spring when Congress considers the NASA budget.

We expect to raise in excess of $100,000 from more than 10,000 contributors by early summer. The money will be turned over to NASA or other U.S. scientists planning to study Halley's comet.

More than just America's prestige depends on this — our very resolve to explore and utilize space is at stake. Tax deductible donations to the Fund may be sent to:

The Halley Fund
357 Saratoga Avenue
Santa Clara, CA 95050.

Van R. Kane, Director
The Halley Fund
Santa Clara, CA

Science Communication

Sir / Ben Mayer's essay in the February Forum made several valid points regarding the dissemination of Voyager and other scientific data. But he left a number of things unsaid and laid arbitrary blame on the scientists for the failure to communicate to the public the marvelous excitement and wonder of the encounter.

Since I am a scientist working on the Galileo project at JPL, I had the opportunity to spend a great deal of time at the Voyager press center during encounter. I observed the goings-on without being directly involved in them.

On one hand we had press people who sat around bored and left the press center — even during closest approach to Saturn — except during the press conferences. Their questions made it clear that some of them hadn't done their homework. It is difficult to pass on the wonder and excitement, the "gee whiz," to reporters who must have the basics explained first. And it is hard for them to pass it on to their readers.

Even those reporters who feel the "gee whiz" may not have the opportunity to express it in their stories. Reporters are supposed to send "solid news" back to the office. Editors want the latest scientific analysis, hypothesis, or opinion, not the "gee whiz." The reporters received from the scientists what they asked for, and the scientists gave what was expected of them. No one asked the scientists how they felt, and it only showed through on a few occasions. Surely the press must share some responsibility for this.

The reporters who wrote "gee whiz" stories had a difficult task before them: explaining the basics and the "gee whiz" to a scientifically ignorant public.

On the other hand, it should not be forgotten that scientists are people, too. Some haven't the patience or do not want to deal with the public (or even their students), and others cannot do so. But the talent and personality to present a subject in a "gee whiz" manner is not widespread in any field of endeavor. It is asking too much to expect all scientists to be exceptional researchers, exceptional scientific team members, and exceptional public educators at the same time — and to be able to do all this work 14 to 16 hours a day, seven days a week during encounter.

We badly need more scientists of all kinds willing and able to express in lay terms the wonderment of forefront research. This is by no means easy, although it's clear the public interest and needs are there.

When people understand the meaning of science and research, the exciting feel of discovery will be more easily expressed by everyone — and there will be more support for pushing back the frontiers of knowledge.

Steve Edberg
Pasadena, CA

Looking

Sir / In the January 1981 issue of ASTRONOMY there is a letter written by Jim Phillips which was entitled "Retinal Exposure." And in response to the comment about visual observations and descriptions being immensely more satisfying than astrophotography, I am inclined to agree.

I also find visual observations much more rewarding since you actually view the object firsthand. It is much more beautiful, especially because of the knowledge that the soft light of all of those celestial objects has traveled all of those parsecs just to settle on the retina of your eye.

Astrophotographs are also quite beautiful to look at, are challenging to make, and have as much scientific value as visual observations, but I think there are too many amateurs more involved in astrophotography than in visual observations. I do not think anything outweighs the beauty of an object as it drifts through the universe and into our field of vision.

Michael De Traglia
Fultonville, NY

An Aperture Revolution

Sir / After reading Forum in March ASTRONOMY, thought you might be interested in what our club has been working on this last year. These projects include apertures of 28", 24", 18", 17.5", 17", two 16½", a 14¼" and a handful of 12½"-ers. Most of these are portable with Dobsonian alt-azimuth mountings. And all of this in a club that, when I joined four years ago, boasted a 10" as the prized possession!

Mel Bartels
Eugene Astronomical Society
Eugene, OR

New Products Needed

Sir / One reason amateur astronomy is so popular today is that the necessary equipment and materials are easy to get from commercial sources. The amateur no longer has to build his own telescope, and new products appear almost monthly. But I think there are still some big missed opportunities out there that some enterprising person needs to take advantage of. To name just three:

Astronomical vacations. This could be anything from access to a good observing site at an existing vacation spot (a ski lodge in the off-season?) all the way up to an astronomical summer camp for adults.

A custom color lab catering to astronomers. Many of us are resigned to having to do our own darkroom work in black-and-white but don't want to go in for the extra expense of color — yet the labs we deal with don't seem to know anything about astronomy. Surely there's an amateur astronomer working for a color lab somewhere.

A color slide film designed for long exposures — a sort of color 103a-O. (Kodak, are you listening?) If cold cameras and hypersensitization kits can sell commercially, then so should this.

Michael A. Covington
New Haven, CT

The Time Is Now...to Save the U.S. Space Program

"...We cannot be indifferent to space, because the grand slow march of our intelligence has brought us, in our generation, to a point from which we can explore and understand and utilize it. To turn back now would be to deny our history, our capabilities." — James Michener

A few months ago, "The time is now, for Reagan" rang out from TVs and radios, and called to us in block letters from billboards and bumper stickers throughout the land. Now, four months after the new administration settled in Washington, campaign slogans are vague memories floating around in our minds with countless other half-forgotten jingles and bromides.

But the Reagan slogan, slightly modified, still has political potential — as a rallying cry to help save an important government function from the budgetary ax. The time is now, to save the U.S. Space Program.

You can make your pro-space voice heard in various ways, and the following two lists will make it easy. In the first are politicians you can write to voice your support as a taxpayer. In the second are pro-space groups you can join to collectively support the space program.

Remember, when you write to your congressman or senators, that 100 personal letters with one signature each will carry much more weight than a petition or a letter with 100 signatures. Each letter will be counted as an individual mandate.

Look under U.S. Government in larger city phone books, or call your local library to find the addresses of your congressman and senators, and write them at their Washington offices. If you can organize only one letter writing campaign, or write only one letter, aim it toward your congressman. He or she represents only about 500,000 people (as opposed to senators, most of whom represent millions) so 50 or 100 letters or even 5 or 10 will have greater impact. If there is space-related industry in your area, call attention to this. Your voice will come in especially clear.

We've listed the heads of the Senate and House committees with funding control over the space program. Write to them, too. Even if they are not your own representatives, they control the purse strings.

Keep your letters short, no more than one page, preferably typed on 8½" by 11" white paper. If you're not much of a letter writer, don't worry. Just write a couple of sentences like these: "As a taxpayer and voter, I am in full support of our country's space exploration program. Please consider this when you cast your votes." It's as easy as that. You can also send a personal opinion telegram of up to 20 words for only $3.50 and have it billed to your phone. Call Western Union for more information.

On the civil side of saving the space program, we have listed a number of space societies you can join. Some are small, with limited volunteer staff, and some are larger and more organized. A few have their own Washington lobbyists who buttonhole politicians on the benefits of a strong space program. Write to these societies at the addresses listed to find out how you can join and what you can do with them to support the space program.

Head for your typewriters today. The future of the U.S. Space Program is very likely in your hands.

Senate (All addresses are Washington D.C. 20510.)

Commerce, Science, and Transportation,
5202 Dirksen Bldg.
Bob Packwood (R-Ore.), Chmn.
Russell Long (D-La.)

Subcommittee on Science, Technology
& Space, (address above)
Harrison Schmitt, (R-N.M.) Chmn.
Donald Riegle (D-Mich.)

Appropriations, 132 Russell Office Bldg.
Mark Hatfield (R-Ore.), Chmn.
William Proxmire (D-Wis.)

Subcommittee on HUD and Independent Agencies,
5121 Dirksen Bldg.
Jake Garn (R-Utah), Chmn.
John Stennis (D-Miss.)

Budget, 208 Carroll Arms Annex.
Peter Domenici (R-N.M.) Chmn.
Ernest Hollings (D-S.C.)

House of Representatives
(All addresses are Washington, DC 20515.)

Committee on Science and Technology,
2321 Rayburn Office Bldg.
Don Fuqua (D-Fla.), Chmn.
Larry Winn (R-Kans.)

Subcommittee on Space, Science, and
Applications, (address above)
Ronnie Flippo (D-Ala.), Chmn.
Harold Hollenbeck (R-N.J.)

Subcommittee on Transportation,
Aviation and Materials, (address above)
Dan Glickman (D-Kans.), Chmn.
Barry Goldwater Jr. (R-Cal.)

Appropriations, 218 Capitol Bldg.
Jamie Whitten (D-Miss.), Chmn.
Silvio Conte (R-Mass.)

Subcommittee on HUD and Independent
Agencies, 2426 Rayburn Bldg.
Edward Boland (D-Mass.), Chmn.
S. William Green (R-N.Y.)

Budget, House Office Bldg, Annex #1
James Jones (D-Okla.) Chmn.
Delbert Latta (R-Ohio)

Space Societies

AMSAT: Radio Amateur Satellite Corporation
P.O. Box 27
Washington, DC 20044

Campaign for Space
300 M St. S.W., Suite 500
Washington, DC 20024

Citizens for Space
1900 Dufour, Suite 16
Redondo Beach, CA 90278

The Halley Fund
357 Saratoga Ave.
Santa Clara, CA 95050

Inter-Space Society
P.O. Box 388
Melbourne, FL 32901

L-5 Society
1620 No. Park
Tucson, AZ 85719

National Space Institute
P.O. Box 1420
Arlington, VA 22210

Organization for the Advancement of
Space Industrialization and Settlement
P.O. Box 704
Santa Monica, CA 90406

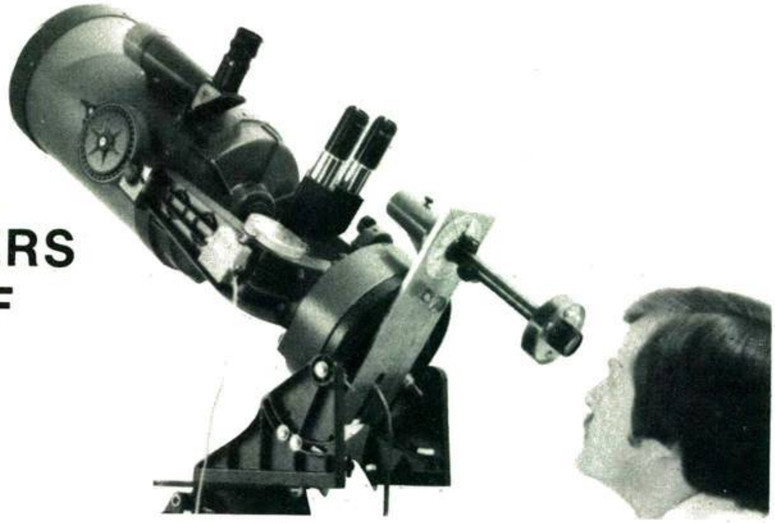
The Planetary Society
P.O. Box 3599
Pasadena, CA 91103

Space Studies Institute
P.O. Box 82
Princeton, NJ 08540

Students for the Exploration and
Development of Space (S.E.D.S.)
372 Memorial Drive
Cambridge, MA 02139

The Viking Fund
357 Saratoga Ave.
Santa Clara, CA 95050

World Space Foundation
P.O. Box Y
So. Pasadena, CA 91030



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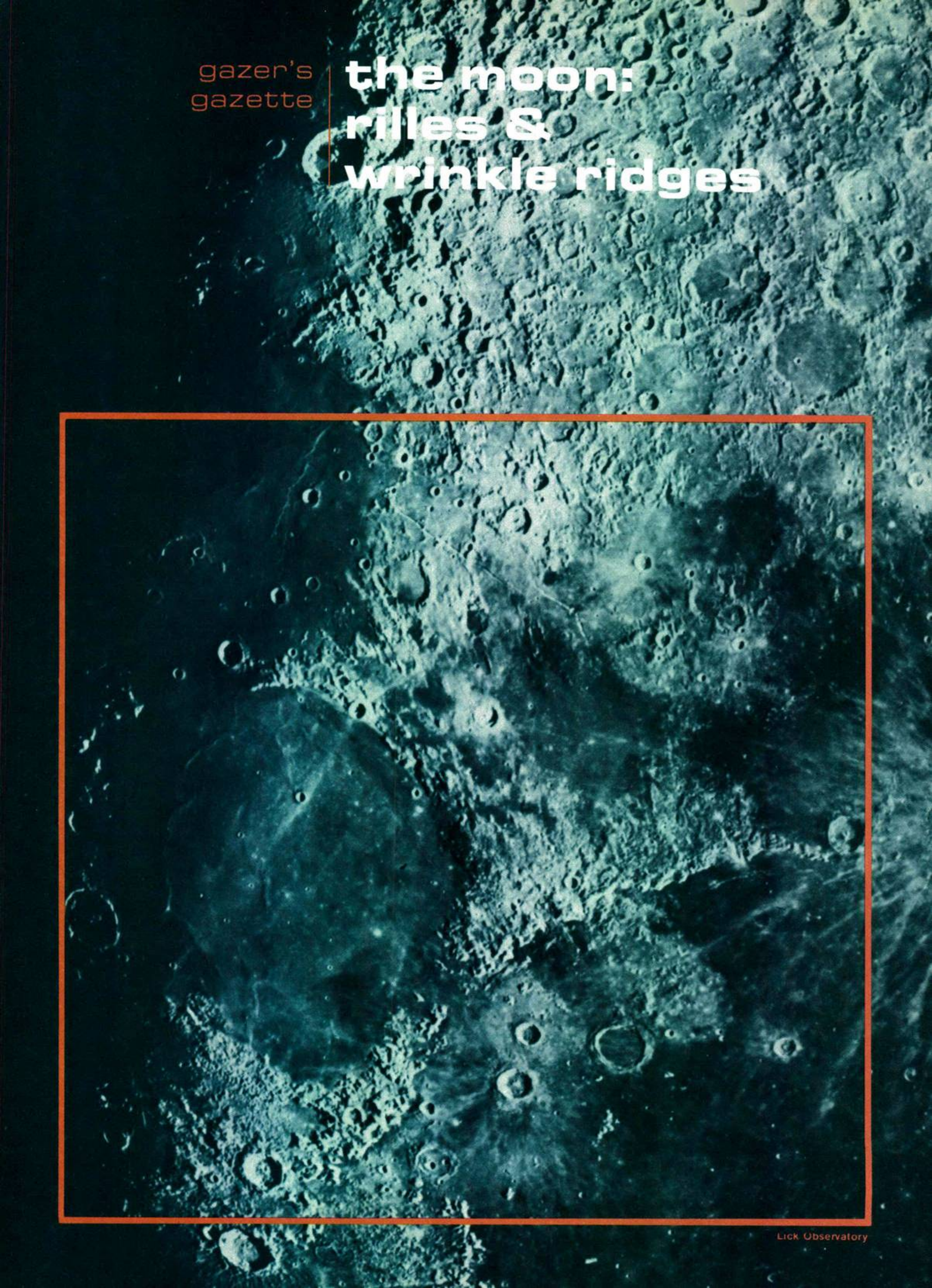
gazer's
gazette

the moon: rilles & wrinkle ridges



Lick Observatory

Everybody with a telescope knows the two things you see on the Moon are zillions of craters and vast dark plains of lava, called maria. And by the time you've learned your way around these, you might be thinking the Moon has little more to show you. Boy, would you be wrong.

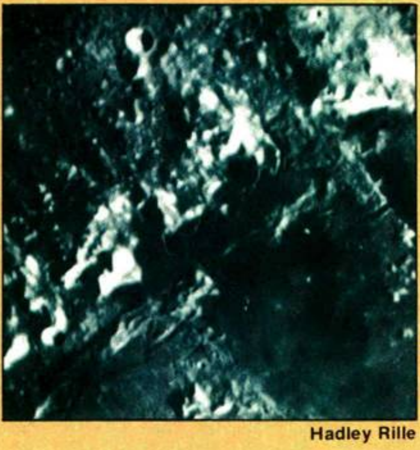
Craters *are* fascinating — and so are the maria — but a lot more has gone on there than just a few billion years of smash! bang! pow!

For instance, have you seen the winding, curvy channel that meanders down out of some highlands and dwindles away at "sea level"? Or have you seen where faults have dropped blocks of ground down a kilometer? Have you seen the vents through which lavas came gurgling out to flood the maria?

Don't forget that craters and maria are only the Moon's most obvious features. Crater impacts are a violently dramatic way of changing a landscape, but they hide as much as they reveal. To speculate on the full story of the Moon, you'll want to observe the smaller, less prominent features of internal origin — like rilles and wrinkle ridges.

Rilles: Lunar Furrows

Rilles are channels or grooves in the lunar surface caused by faulting or volcanic action. Because they can be created in several different ways, they take on one or another of four different shapes: irregularly branching, straight, sinuous (winding), and arcuate (or arc-shaped). Let's look now at some typical examples and see what they can tell us.


Lick Observatory

Hadley Rille

At the center of the Moon's earthside hemisphere is a small dark expanse of mare material called Sinus Medii. Roughly in the center of Sinus Medii lies a crater, 26 kilometers in diameter, called Triesnecker. Across the mare to the east of the crater spread the Triesnecker rilles — an irregularly branching group of cracks ranging in size from obvious down to barely detectable. Don't look for them under high Sun angles — around First or Last Quarter is best.

Jiri Bunata

Ariadaeus and Hyginus Rilles

Although an observer once described the Triesnecker rilles as "nearly bottomless," orbital photography and careful mapping has shown them to be about 500 to 750 meters deep and 1 to 1½ kilometers wide. But when you look at them under grazing sunlight, it's very easy to think those black cracks are bottomless.

Just to the northeast of the Triesnecker rilles is a crack in the ground having a very different appearance: the Hyginus rille. Wider and more prominent than any of the Triesnecker group, the 180 km long Hyginus rille is single, runs almost arrow straight in both of its two sections, and, in places, appears to be a chain of craterlets.

Lunar geologists think that the Hyginus rille is a *graben*, a structure in which the ground drops between two faults. In this model, Hyginus crater is a large circular collapse feature — a volcanic vent perhaps — and the several craterlets in the rille are minor venting sites. From the simplifying perspective of 400,000 kilometers, Hyginus crater's location at the break in the rille's direction certainly seems like a lot more than plain happenstance.

Gazing into the rille, you may not see the little craterlets at first. But during moments of good steady seeing, they'll suddenly pop into view, especially in the northern parts.

Another interesting aspect to the Hyginus rille is its relation to the general sculpturing of the landscape — a northwest/southeast trend radial to Mare Imbrium and a relic of the impact event there. With the surrounding rocks greatly shocked and fractured from the mare impact, you would expect rille-making fault lines to run radially, too. Yet only the northern half of the rille is aligned with the trend. The southern half (beyond Hyginus crater) extends to the east-southeast toward a larger and longer rille running parallel to it — the Ariadaeus rille.

The fact that the Hyginus and Ariadaeus rilles have separate names tends to obscure their similarities — in fact, as you look at them, you'll find it hard not to think of them as one system. The Ariadaeus rille extends for more than 240 kilometers and has an average width of 3 kilometers; its depth is probably 500 meters or so.

Most likely a graben, the rille shows little sign of crater vents, but in at least one place it has a slight "jog" in its course. This is where a fault (aligned with the Imbrium sculpting) has offset the trend of the rille. At its western end, a small, shallow rille extends over toward the Hyginus rille.

In a telescope, all three rille systems here are superb — in few other places can you see the geology so clearly. Provided the lighting is right (around First or Last Quarter), even moderate powers will reveal the rilles. Higher powers and steady seeing will show far more.

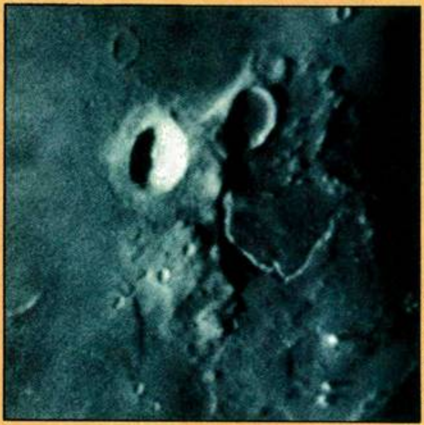
Lunar Rivers?

Among the other two types of rille, the most interesting is the sinuous. Strongly resembling terrestrial river valleys, they hint at a lunar past far wetter than today.

Along the eastern shore of Mare Imbrium, where the Apennine Mountains rear abruptly out of Palus Putredinis, snakes a long rille named for Mt. Hadley. Chosen as the target for Apollo 15, Hadley Rille has a total length of about 30 kilometers but only the southern half of that stands out distinctly enough to be seen from Earth. Where Apollo 15 landed, the rille is about 1½ km across and 500 meters deep.

Finding the rille is a small challenge in itself. But when you look down on the mare surface in front of the Apennines, suddenly you'll see it — a dark thread on the lighter grey of the mare. Once you spy it, tracing its curves and twists with moderate to high powers (100x to 250x) will be easy.

But where did it come from? Unfortunately for would-be lunar colonists, the samples the astronauts brought back rule out any wet origin for Hadley Rille. Instead, the startling "river bed" is the remains of a crack where lava flooded out onto the mare.


Jean Dragesco

Schroeter's Valley

Another sinuous rille, even more tantalizingly stream-like, is the famous Schroeter's Valley near the bright crater Aristarchus. The valley originates in a hilly region to the northwest of Aristarchus and its neighboring crater, Herodotus. It runs first north and then curves over toward the west, eventually making a semicircle and petering out when it leaves the hills at the shore of Oceanus Procellarum, 140 kilometers from where it began. The rille's starting point — a crater about 15 km across — has been called the "Cobra's Head," and lies about 4 km higher than the mare end of the valley.

Schroeter's Valley is actually two rilles. One is about 4 to 5 km across, 1 to 2 km deep, has a flat floor, and is what most observers mean when they refer to the valley. The other is a narrow channel, about 500 to 1000 meters across and 250 to 500 meters deep, that meanders in a *very* fluvial manner down the flat floor of the valley.

Even a small telescope will reveal Schroeter's Valley to you, but you'll need at least an 8-inch telescope, high power, and (most importantly) superb seeing to make out the "little rille" on the valley floor. The best time to look is a day or two before Full Moon.

Naturally, the big question is: Was the little rille carved by water? Once again, no one knows for sure. Despite the strong resemblance to a stream bed, it's more likely the whole feature was volcanically produced — perhaps by gigantic ash-flows. Many theories have been advanced, including water erosion, but each has serious flaws. This important site is slated for detailed investigation when we return to the Moon.

You Can't Stretch a Rock

The fourth and last kind of lunar rille is the arcuate. Typified by the three gently curved rilles at the eastern side of Mare Humorum (between the craters Hippalus and Campanus), they best resemble what you'd get if you bent the Ariadaeus rille in a broad arc. Because they are wide and shallow, you'll see them best under relatively low angles of sunlight — a day or two after First or Last Quarter.

Look carefully and you'll notice they cut across all kinds of terrain — crater walls, hills, flat mare — showing that they are some of the most recent features of the landscape. Only new, fresh craters intersect them.

The likeliest theory for their origin claims they are grabens formed when Mare Humorum was flooded with heavy basalts. As the basalt flows warped the interior of the basin downward, the rocks at the edge — being arched over and down into the basin — snapped from the tension along concentric cracks and faults.

Ropy Strands of Rock

Some geologists think the same process created another distinctive feature on Mare Humorum — wrinkle ridges.

If you filled Mare Humorum with lava and let the basin sag downward, you'd expect to see the top surface crumple a bit, much as the skin of your palm does when you cup your hand. And sure enough, just west of the arcuate rilles, there's a network of concentric ridges snaking across the mare surface.

Looking almost like strands of rope, they braid and twist in an eye-catching pattern, belying their actual low height. Few wrinkle ridges rise higher than about 300 meters, but on flat mare surfaces they stand out very well.

While the Mare Humorum ridges are probably due to compression in the top layers of the mare-filling basalt flows, wrinkle ridge origin in other places is not so clear. Mare Imbrium, for example, has a great many all over — which you'll discover night-by-night as the morning terminator advances from First Quarter to Full.

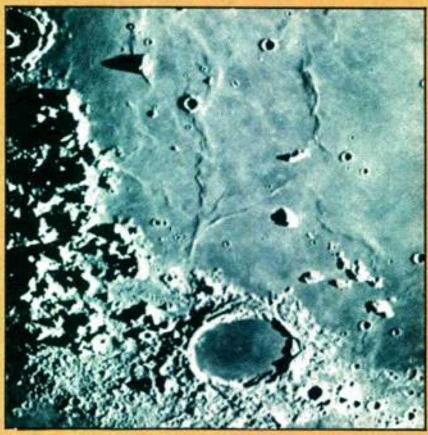
Yet notice how few of the ridges lie concentric to the mare border; in the center of Mare Imbrium many extend in a north-south direction. One geological suggestion has been that instead of being squeezed-up surface layers, the ridges mark the faults through which the mare basalts flooded out. This would mean that wrinkle ridges are the "last, dying gasp" of volcanic activity that froze in place ages ago.

A look at the ridges on Mare Serenitatis is even more interesting: on the eastern side of the mare, you'll see a large, relatively high wrinkle ridge. Easily seen even in small telescopes, this wrinkle ridge is so prominent as to have its own name, the Serpentine Ridge.

At its northern end, the ridge appears as several low and indistinct strands. But just to the south of the crater Posidonius, these strands unite to become a knotted hummock that, with twists and offsets in many places, meanders south and a little west toward the crater Plinius. Near the southern part of Mare Serenitatis, the Serpentine Ridge breaks up, dividing into two main strands, one extending southeast past Plinius, the other trending northwestward toward the crater Bessel. Along the western side of the mare, there are two other wrinkle ridges, but not as high and wide.

Try mentally putting yourself on the ground up there. Think what a grand sight you'd see as this broad hill, stretching from horizon to horizon, loomed over the flat mare!

The basalt flows of Mare Serenitatis are unique among the maria for their marked heterogeneity: interior expanses are generally lighter in color than those along the shores. You can see the contact between the two rock units most easily in the southeastern part where Mare Serenitatis adjoins Mare Tranquillitatis.

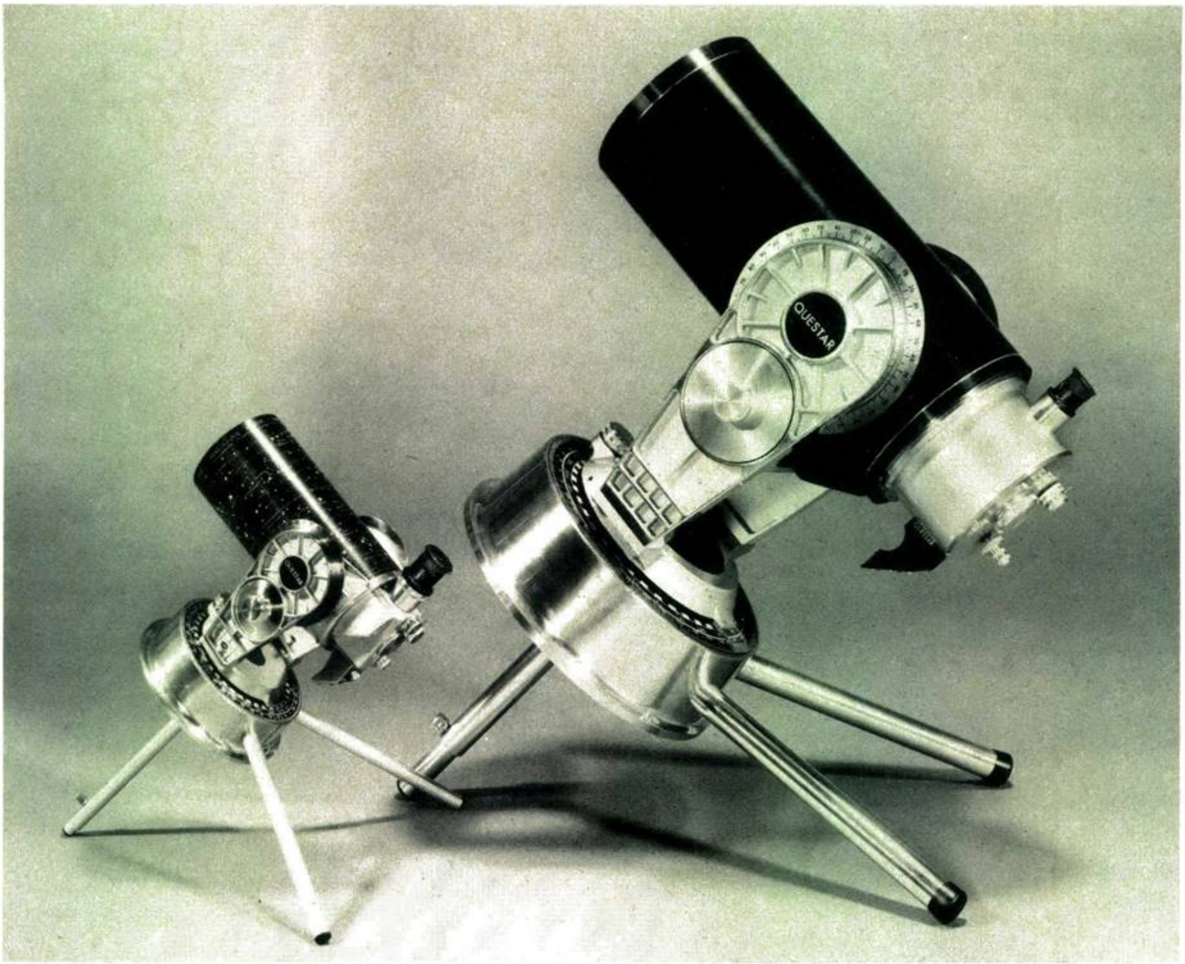

Lick Observatory

Wrinkle Ridges near Plato

This has convinced scientists that the flooding of Mare Serenitatis was not an all-in-one event — but how it ties in to the nature of wrinkle ridges isn't very clear. As you can see, the ridges appear to be only loosely connected with the contact between the light and dark flows. Perhaps they are compression ridges — or maybe they are clogged-up vents along a fissure.

But just as we saw with rilles, it's unlikely there's any one origin for all wrinkle ridges — some will prove to be compressional squeeze-ups, some lava extrusions, and others uncollapsed lava tubes. Whatever their origin, rilles and wrinkle ridges certainly provide hours of fun for the backyard lunar geologist.

— Robert Burnham



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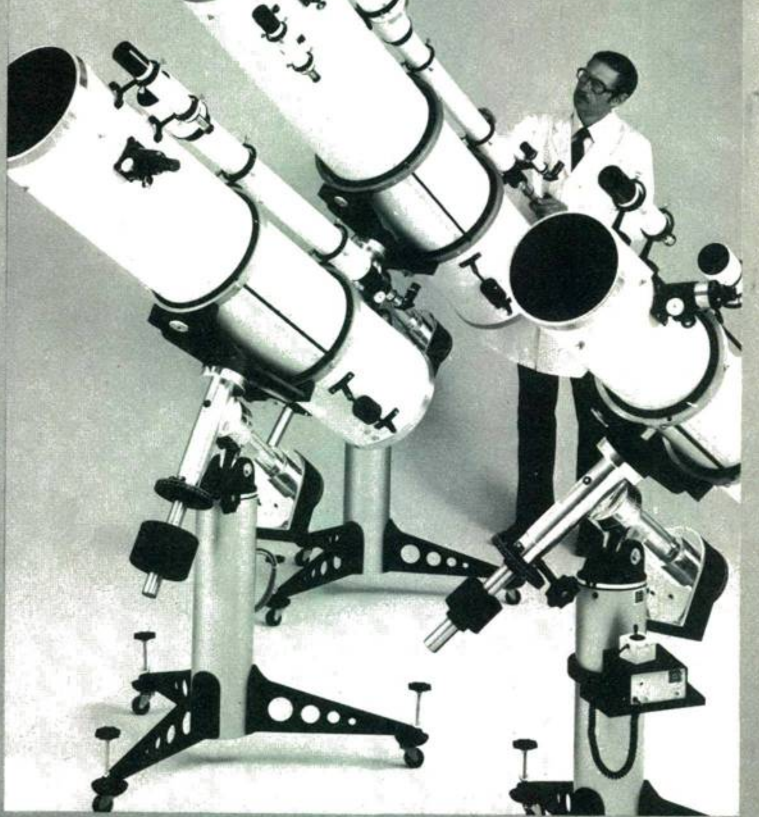

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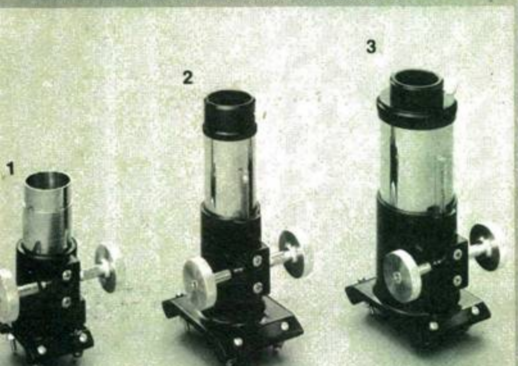

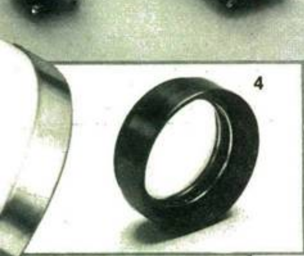

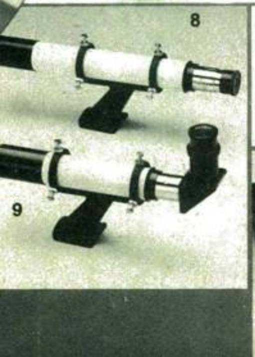

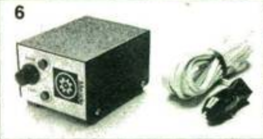

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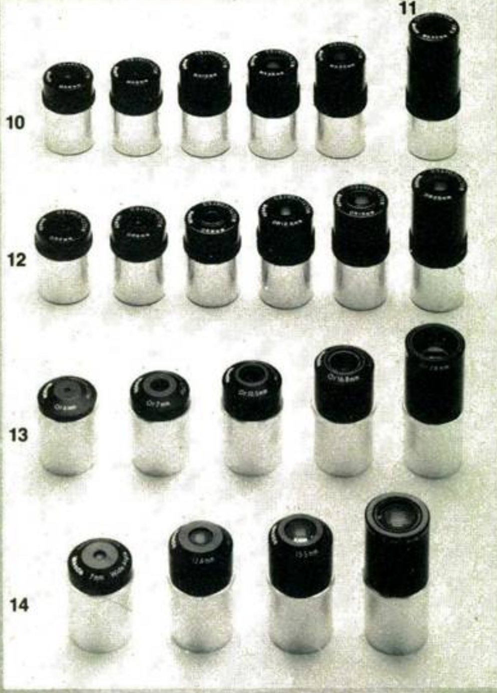

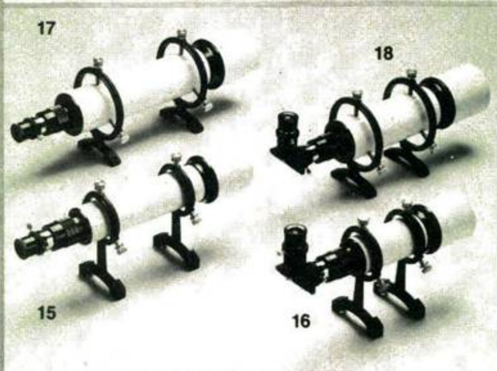

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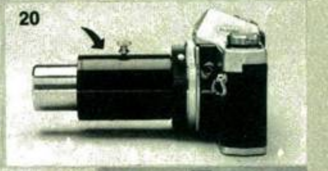

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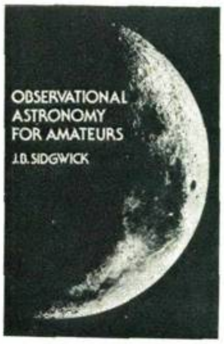
J. B. Sidgwick



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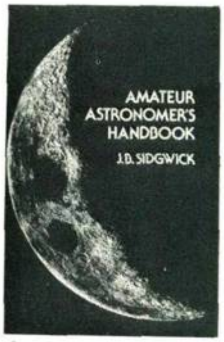

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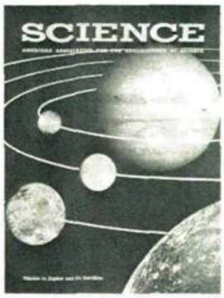

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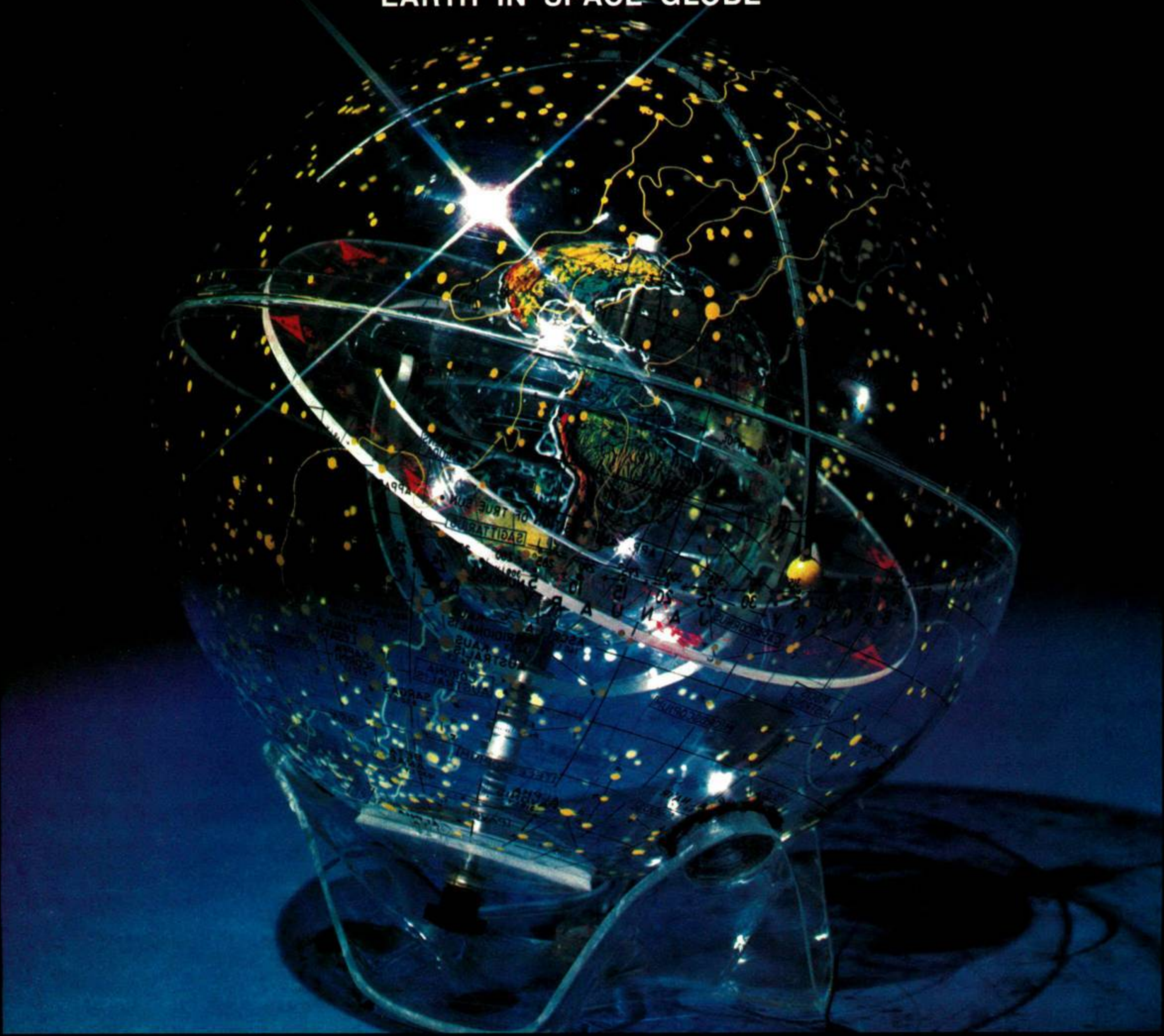

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photography
in
astronomy

hypersensitizing, part 2

by Roger Sliva

Last month we looked at the significant advantages astrophotographers can gain by hypersensitizing their film with forming gas. This simple treatment of your film will give an amazing increase in speed as well as better color balance and greater success in copying.

But you will need to invest in some equipment: this month we will tell you how to build your own hypering chamber at home.

The essential elements are:

- An airtight chamber to hold the film.
- Two valves: one to allow evacuation of the chamber and the other for introduction of the hypersensitizing gas.
- A pressure gauge to determine the pressure within the chamber.
- An insulated box to hold the chamber and contents at a fairly constant elevated temperature.
- A heat source connected to a thermostat to bring the chamber and contents to the correct temperature.
- A small vacuum pump to remove air from the chamber.

In addition, you will need a supply of bottled "forming gas" and a regulator suitable for the gas supply. Forming gas is a mixture of nitrogen with about 8% hydrogen. It can be obtained from a local bottled gas or welding supply company. It's a good idea to spend the extra money for a lab test to insure the correct mixture, since there could be as much as a 2% error either way in untested forming gas and this could affect your results.

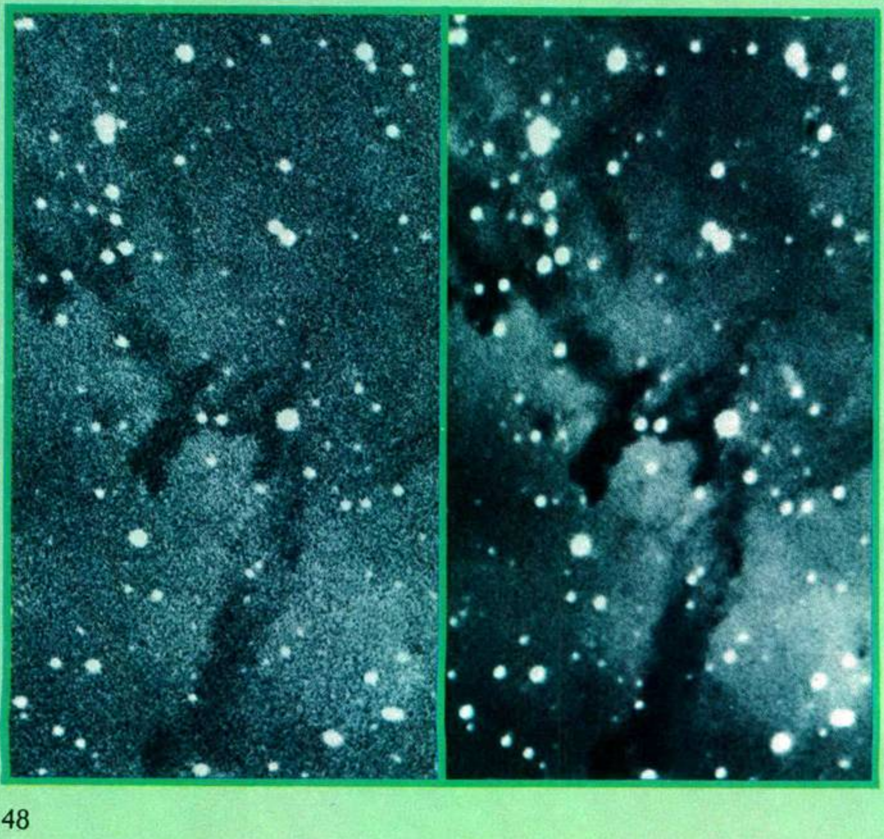
WARNING: Although the percentage of hydrogen in forming gas is low and relatively non-explosive, tank pressures are high and care must still be exercised!

While you can use any metal to make your own hypering chamber, aluminum is good because it's light and workable. Start with a thick-walled tube of sufficient length and diameter to hold the number of cassettes you wish to hypersensitize at one time. To conserve gas, keep the size small (the two chambers shown in the photographs hold 2 and 4 rolls).

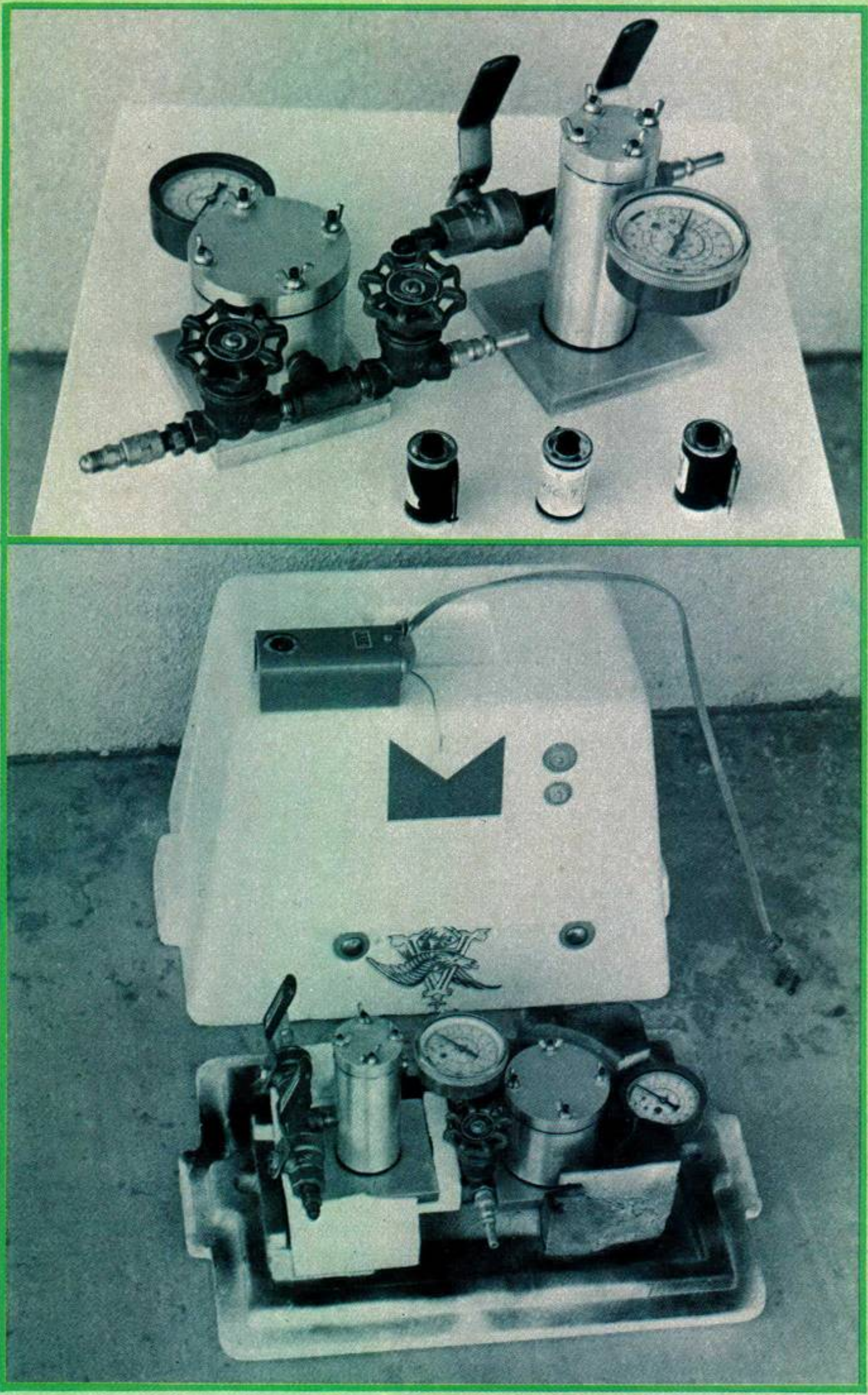
A thick wall (½") is necessary to accommodate the 10-24 screws and studs which hold the end plates securely in place. These end plates are also ½" aluminum with the upper end machined to match the tube. You will need two gaskets cut from 3/32" flat rubber (or a heavy duty inner tube) to ensure an air-tight seal. Use wing nuts to clamp the removable top plate tightly onto the chamber.

A vacuum-pressure gauge purchased from an air conditioning supplier is essential, and can be installed anywhere in the closed part of the system. (I placed it on the opposite side from the valves for balance.)

All fittings are ¼" brass with liberal amounts of pipe dope applied to prevent gas leakage. I have tried a number of valves, including ball types



Left: These photos of the Rosette Nebula were taken by Edgar Everhart with the 16-inch telescope of the Dick Mountain Field Station of Chamberlain Observatory. The photo at far left was taken on untreated 103a-F film, while the near left is a 60-minute exposure on hypered 2415. Everhart treats 2415 film for a short time at high temperature in a high vacuum chamber. Right: Roger Sliva took this photograph of the Lagoon Nebula (M-8) in Sagittarius on hypered Ektachrome 400.



These photos show the hypering chambers constructed by the author. Note the use of a styrofoam cooler equipped with a thermostat. One of the chambers shown holds two rolls of film, and the other holds four. A larger chamber, designed to hold a reel of film removed from its cassette, will speed up this process.

advertised to hold up to 250 pounds, but my favorite is the rubber stopper type because it allows for a slower and more controlled evacuation. (I had to repack one expensive ball type to get it to stop leaking.) A pressure relief valve should be added as a safety precaution — an automatic adjustable type will prevent an accidental overfill.

When you have completed the chamber, test it for leaks by pumping air into it to a pressure 1½ times the greatest you will be using (for most, this will be about 25 psi). If no leaks are noticeable right away, set the apparatus aside for several days and check the pressure. If it drops more than 20% in two days, for example, you have a significant leak somewhere in the system.

Temperature stability is important for consistent results. An excellent and stable heating container can be made from an inverted styrofoam cooler. Attach a household-type thermostat with a 3° on-off range to the cooler and place the heat sensor inside. Connect a small high-intensity 40 watt bulb to the thermostat on the inside. Make a reflector from a tin can cut in half lengthwise to keep the bulb from melting the styrofoam. Use large washers for all attachments to keep the soft plastic from collapsing.

A simple 30-minute test with a jar of water and a good thermometer will determine the accuracy of the thermostat. The air temperature in the container may vary, but the liquid will remain quite constant. The light bulb will burn about 3 minutes out of 20, depending on the ambient room temperature.

The operating sequence for a typical hypering run is as follows:

1) Open the chamber, place the film inside, and close it.
2) Close both valves.
3) Open the pump valve and pump out the air.
4) Close the pump valve.
5) Open the gas valve and slowly add forming gas to the correct pressure.
6) Close the gas valve.
7) Place the gas unit inside the heating chamber.
8) Set the thermostat.
9) Wait the time necessary for hypering to occur.
10) Remove the gas unit from the chamber and allow it to cool.
11) Vent the forming gas. (Be careful; breathing hydrogen is not especially good for you.)
12) Open the chamber and remove the film. Refrigerate it if you don't plan to use it right away.

If you want to purchase a small amount of sensitizing gas, Dr. Jack Marling of Lumicon (891 Laguna St., Livermore, CA 94550, (415) 447-9570) sells a 35 liter tank (about 1¼ cubic feet) with 8% hydrogen for $49.50. Refills are $24.50. And if you don't want to tackle the job of building your own unit, a complete kit, which includes a chamber, heat tape, gas, and a hand vacuum pump, is also available from Lumicon for $199.50, and a kit for fast hypering of unrolled film is $249.50.

Follow the recommendations given in last month's article for sensitizing your film, but don't be afraid to experiment with different temperatures, pressures, and times until you find what works best for you.

Roger Sliva is Associate Professor of Auto Body Technology and Chairman of the Mechanical Trades Department at Riverside City College in Riverside, California. He is a past president and currently chief observer of the San Bernardino Valley Amateur Astronomers. Mr. Sliva was assisted in the construction of his hypering chamber by Roger Deyoe, who also helped with the comparison tests.

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getting away to it all

by Tom Wilson

Have you had a winter-long itch to get out of the house and into the country to do some satisfying observing? Well, spring is finally here and summer skies are coming soon.

Most people don't realize how easy it is to take an overnight trip to a first-class viewing site and enjoy camping as well. If you plan ahead and take advantage of our excellent national parks and forests, escaping to the star-filled country darkness is simple and less expensive than you might think. You don't even have to skip work or take out a loan — all you need is a free weekend.

You'll soon discover that astronomy country-style offers much more than a simple escape from streetlights. Getting away for even one night is a small vacation. After all, a gentle evening of sweet mountain air beats getting redeye from TV. Kids love the adventure of a night in the woods and are eager to learn about your hobby in nature's own classroom. Dark skies are also the place to find the limits of new equipment, take special photos, and really enjoy astronomical events.

In between your nighttime sessions, the national parks and forests offer a variety of daytime outdoor pursuits, like hiking, swimming, and climbing...something for everybody, as the saying goes.

But before you jump in the car, a little planning is in order. A minimum of legwork now to determine where you are going and what you'll need can help make a good idea into a great trip.

Start in the phone book under U.S. Government. To find the closest national forest look under the Department of Agriculture. National parks are listed under the Department of Interior. If you don't find a listing, contact the Regional Offices listed under U.S. in the accompanying box, and they will gladly help you find a suitable campground. Don't forget the state parks, either. They too are listed in the phone book, and like the national facilities, they are ultimate camping bargains.

Picking the park or forest which is perfect for you is impossible, but by keeping within a few guidelines you can make a good choice the first time. Hundreds of suitable spots await those in the West. In the South, Fort Pickens National Park, the Everglades National Park, and the Great Smoky Mountains National Park will do nicely, along with numerous national forests. Farther north, the Appalachian, Allegheny, Green, and White Mountains are excellent choices. Midwest enthusiasts unfortunately have fewer locations to pick from and may have to settle for wooded areas and open plains away from lights. But also look for nearby state, and even county parks that allow camping — they can serve you well for a night under the stars.

Each park and forest offers different services and has a different price. Most provide campsites, picnic areas, drinking water, and bathrooms. Larger facilities can meet every conceivable need, while the smallest may offer nothing more than spartan amenities. To find out which campgrounds allow 30-foot motorhomes and which don't, ask the regional office for their map or guidebook. Prices are available only from each campground. Typical figures range from 50¢ per person per day to $3 per vehicle per day. If you can afford to drive there, you can certainly afford to stay! Additional minor fees are sometimes collected for keeping pets overnight, extra vehicles, large groups, etc. Avoid these costs by leaving all non-essentials at home.

Select your campground by geographical location — astronomically speaking, the higher the better. Mountains are the number one choice of both amateur and professional astronomers for two reasons: clear air and dark skies. Mountains are above most problem weather. Fog, low overcasts, smog, and haze are flatland phenomena, especially along coastal strips. Average-sized mountains are covered with forests and meadows which break up winds and promote still air, and light pollution is usually too distant to matter in the hills. If there are no mountains nearby, look for wooded areas or high plains.

Certain types of topography are poorly suited for observing. Deserts suffer from wind and rising heat waves. Even on annoyingly cold nights, the stars dance and twinkle with maddening consistency. Beaches are another poor choice. Admittedly fun for camping, beaches often have quite a bit of moist air passing over them. Fog and cloudiness often develop after dark, and even on clear nights the air may not be still.

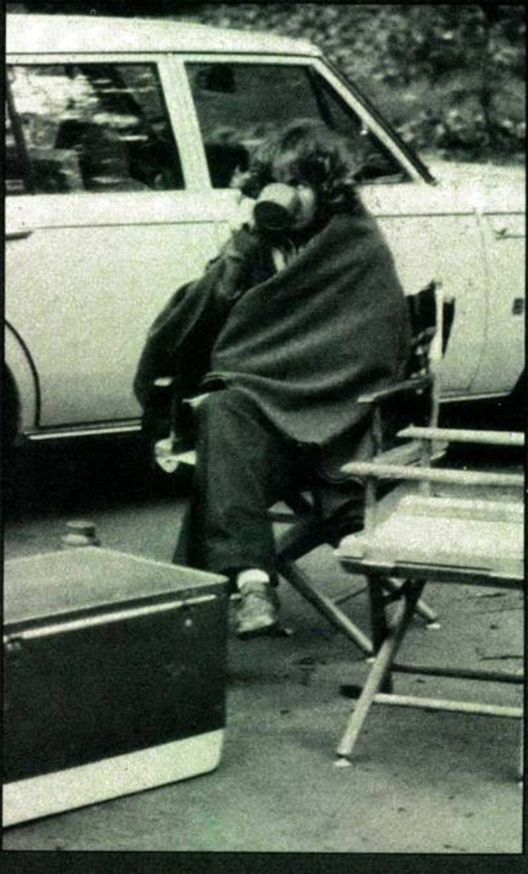
If you have a choice, pick still air over a slightly darker sky. Imagine looking upward from the bottom of a swimming pool — it matters less if the water is slightly dirty (smog) or lighted (light pollution) than if it's choppy (wind, heat waves).

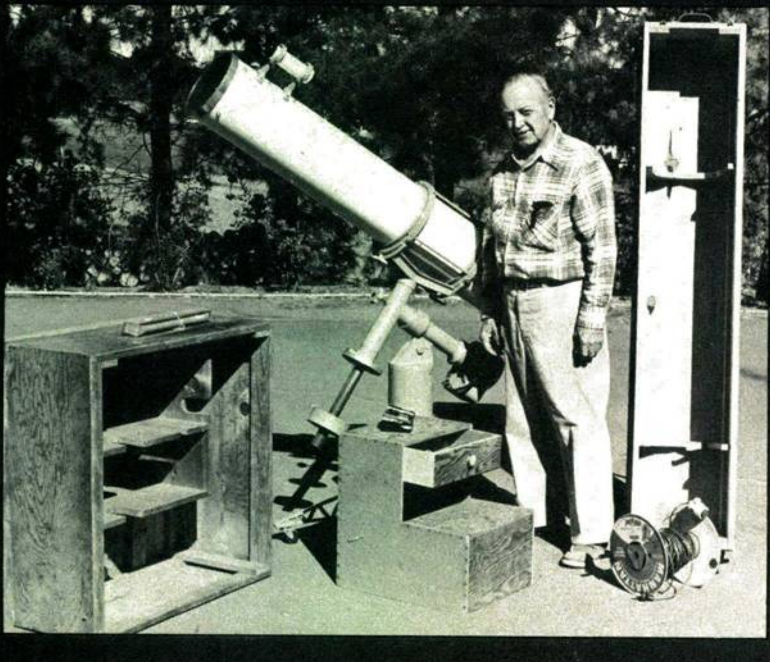
Even after arriving at the campground there are good spots and so-so spots. You may have to camp in one spot and observe in another. Keep in mind that a northeastern-facing slope doesn't get the afternoon Sun, and will be cooler with less rising warm air than a southwestern slope. Of course, all objects rise in the east, and the eastern sky darkens first, so you'll see more objects earlier in that direction. Some of the best observing spots are in parking lots where the trees have been cut back to show more of the horizon. The flat surface makes setting up easy, and you can work right out of the car. Ranger lookout towers are another likely spot. They have great views, revealing the excellent horizons available on mountain tops.

Sites to avoid include those areas smack in the middle of other campers.

RANGER STATION

Photos by the author





If nothing else, most outdoorsmen are early risers. You might not like the neighbor's kids playing frisbee over your tent at 6:30 a.m. after you stayed up counting meteors. He's probably the same fellow who had the wick turned up all night on a blindingly bright Coleman lantern, so you don't want to camp near him anyway. If you can, stake out a quiet spot at the far end of the campground instead.

Camping Gear

Luckily, the park system is set up for car camping. That means you'll take the car right into the campsite with you. This is the easiest camping style, and will interest those who may not be enamoured with roughing it.

Remember, when it comes to camping, "less is more." Don't fall prey to the idea that the car should carry everything it can hold. For a hassle-free weekend, keep it simple. Make use of packaged dinners, or cook up a one-pot meal which needs only warming beforehand. Cold sandwiches will do for lunch, although you'll probably want a hot breakfast. Snack on fruit and nuts, not sweets. All your food should easily fit into a medium-sized cooler.

Don't bring a cookstove unless the campground doesn't have built-in grills. Plan on bringing your own fuel, though (charcoal, for example).

Sleeping under the stars is half the fun of going to the country, but a tent, even a pup tent, is a good idea for privacy and weather protection. Station wagons and vans lack only padding for a good night's rest.

Equipment

Successful camping depends on what you leave at home, not how much you take. Keep this in mind when picking out your equipment. After all, whatever you pack, you'll have to unpack upon your return — maybe while wondering why you brought it.

Casual stargazers should take nothing more than a star chart and a pair of binoculars. With them, you can see thousands of interesting objects. These two pieces of equipment are the foundations of any expedition, whether it's into the backyard to check the seeing or off to the hills for a week. Perhaps you don't use them much at home, but in a darker sky and unfamiliar surroundings getting "lost" is easier than you think.

A dim flashlight is also a necessity. This could be nothing more than a normal flashlight covered with red cloth, or the ready-made type. Reading a star chart or picking out the right objective is a lot easier with such a tool.

Most observers want to take a telescope in addition to the chart and binoculars. Fine, but resist the "bigger is better" temptation, at least on the first trip. The effort of lugging an 8-inch f/10 reflector around could spoil an otherwise fine outing. Test your dark sky process with a four-inch reflector or one of the folded-optics telescopes. The smaller unit makes packing and unpacking less of a chore, and if you *do* damage it while traveling (not unheard of), it won't be as much of a catastrophe as if you bumped your Quasetron UltraScope.

Save the larger telescope for future trips and make the first run a break-in affair. It's a good time to find the limitations of your camping gear, and scout out some suitable observing sites for a larger instrument.

Whatever size scope you take, be sure to pack it securely. The original shipping materials work extremely well. Small telescopes will survive the ride if they are wrapped in a sleeping bag, then set on top of the heap. To fully protect larger scopes, hammer up a plywood box and line it with dense styrofoam. When cut to shape, the styrofoam is a first-rate shock absorber. Such a box is also just the ticket for home storage. Inexpensive plastic boxes are available for lenses and filters. They protect from both shock and dew.

One problem you may wish to ignore until later trips is power for a clock drive. Don't count on it, but your favorite campground may have 110 power. If so, you'll probably need a long extension cord. Since most drives need 110 volt 60 Hz AC power, you can purchase a 12V to 110V inverter or "drive corrector." This is a fairly expensive piece of equipment, but if you'll be using it many times, it's worth the investment.

Dewing isn't as much a headache at high elevations as it is at lower elevations, but it could be troublesome — so don't leave your dew caps behind. The eyepiece box already mentioned keeps dew off — if you remember to close the lid. Even a raincoat could double as a tarp — just cover everything where it lays on your folding table or tailgate. It isn't as convenient as individual boxes, but it doesn't cost anything either.

Keeping warm while observing is a subject unto itself — see ASTRONOMY, December 1980. Even in the summer, don't be suprised it it's cold at night. In the mountains as a rule, the temperature normally drops four degrees Fahrenheit every thousand feet you ascend. At five or six thousand feet it might be 20 degrees cooler than in your backyard, so take a blanket to wrap up in, well-insulated foot gear, and a stout jacket. Ankle length coats are excellent for keeping body heat in. If you don't own one, try a heavy bathrobe. A blanket or unzipped sleeping bag is a must while counting meteors or sitting in the folding chairs you brought along. Your non-observing companions will especially appreciate such comfort items.

Once back in civilization, plan ahead to the next trip right away, before you forget the lessons you've learned. Make a note of unused items and trade their weight for something you needed but didn't have. If the equipment — camping or astronomical — didn't hold up, repair it right away. Then you won't be surprised the next time out. And check Sky Almanac for upcoming celestial features — you may wish to time your next trip with a special event!

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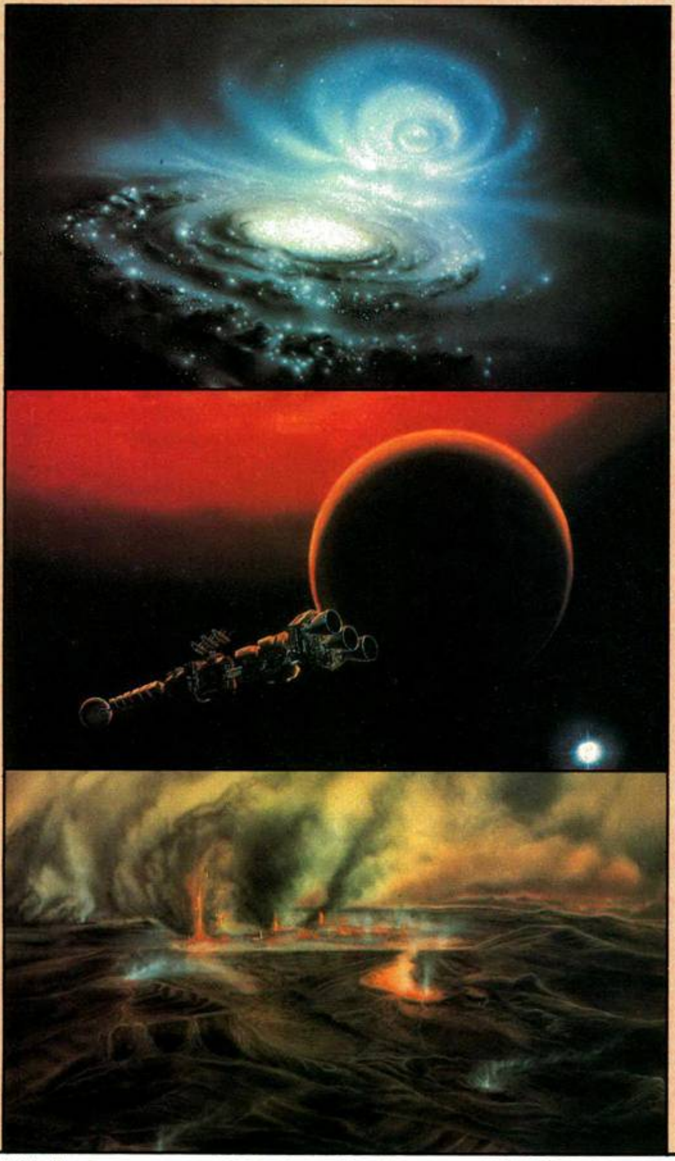

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AstroNews

Space Science Budget Slashed

The Reagan Administration, in an attempt to curtail government spending, has formally proposed a budget which, if approved by Congress, would cripple the United States' role and capability in space exploration for the next decade.

The proposed budget for NASA slashes $468 million from the original $6.7 billion request for fiscal year 1982, approved by the outgoing Carter Administration. $196.5 million of the cut would come from NASA's Office of Space Science, making it the hardest hit division in NASA. The Space Shuttle, necessary for the launch of military payloads, emerges relatively unscathed — except for cuts in its purely scientific missions.

The cuts, less severe than those originally proposed by the administration, still mean cancellation of U.S. participation in the International Solar-Polar Mission, curtailment of the Spacelab flights of the Space Shuttle, and elimination of the Solar Electric Propulsion System (SEPS) development program essential for future exploration of the solar system.

The administration's program would also kill hopes for a U.S. mission to Halley's Comet and delay the Gamma Ray Observatory project for several years. The Venus Orbiting Imaging Radar (VOIR) project has been saved from elimination by a continued but reduced funding level which will delay the launch from 1986 to at least 1988. The Galileo mission to Jupiter, already postponed once and originally targeted for cancellation by presidential advisors, may be delayed again.

The Spacelab flights of the Space Shuttle, non-military scientific missions, were originally scheduled to number about 12 by 1986. The Carter budget cut these to 4 or 5 missions in 1986, and the latest cuts may reduce the number of Spacelab flights to one or two per year. The Astronomy and Astrophysics Mission, scheduled for Spacelab 2, will probably be canceled.

Elimination of the Space and Terrestrial Applications program — designed to benefit private industry with new technology resulting from the space program — would save $12 million, according to the new administration's figures.

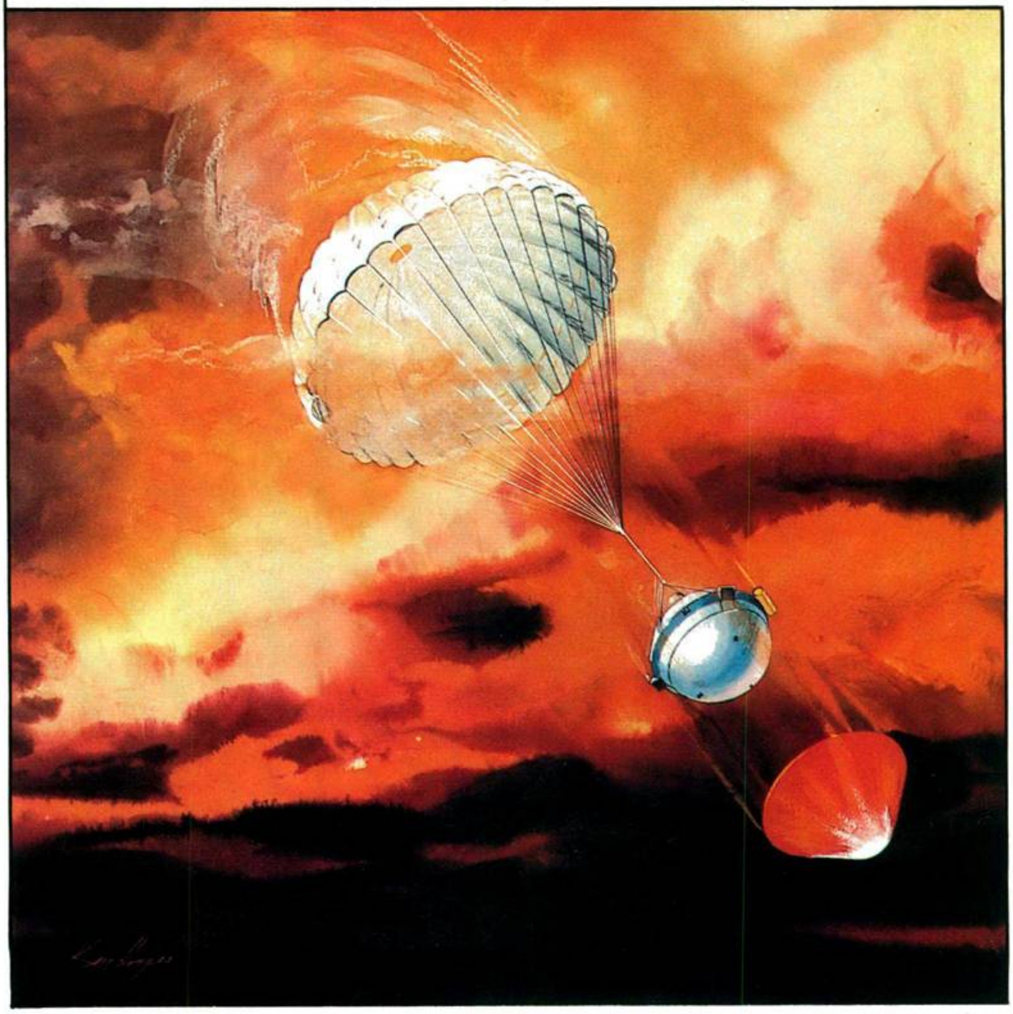
The cancellation of U.S. participation in the Solar-Polar Mission seriously damages prospects for future cooperative enterprises with the European Space Agency (ESA). The Solar-Polar Mission would have sent two spacecraft out to Jupiter, where the giant planet's gravitational field would swing them out of the ecliptic plane into trajectories over the solar poles. One spacecraft would have been sponsored by NASA and the other by ESA. Now only the ESA probe will fly.

ESA is already skeptical about U.S. commitment because of NASA's withdrawal from a joint mission to comet Halley. At considerable cost, ESA went ahead with plans for a Halley mission of its own (Giotto), and subsequently rejected a NASA bid for a role in the mission. Space officials doubt ESA will trust future proposals for cooperation.

The Galileo Jupiter Orbiter and Probe mission, originally scheduled to be cut, was saved by the cuts in other areas. This preserves U.S. presence in planetary exploration. The Reagan Administration, however, still proposes a two-year delay in launch of the mission, but will allow NASA the option of retaining the already postponed schedule by making greater cuts in other areas.

The aerospace industry itself will not be harmed by cuts in NASA's budget. The Reagan Administration is planning to ask Congress for a $26.4 billion increase in military funding, including $2.4 billion for a modified B-1 combat aircraft.

A red-hot nose cone separates from the probe portion of the Galileo spacecraft as it "hangs on the shrouds" and samples the atmosphere of the largest planet in the solar system. NASA.



National Astronomy Week

The White House, through the encouragement of NASA, has formally proclaimed May 3 through May 9 National Astronomy Week, according to NASA Public Affairs Director Charles Redmond. May 9, slated as National Astronomy Day even before the White House proclamation, will conclude the week, which is intended to increase nationwide activity and awareness in the space sciences, with both amateurs and scientists participating.

During National Astronomy Week, NASA will act as a conduit for information on activities throughout the U.S. It will publish a list of astronomical gatherings and distribute it to amateur and scientific groups throughout the nation.

NASA collaborated with the Astronomical Society of the Pacific and the American Astronomical Society to choose the time for Astronomy Week. The first week of May affords generally clear skies across the entire country.

Amateurs or amateur groups that wish to participate in the week by sponsoring events, or simply wish to be informed of other events, should call Charles Redmond at the NASA Public Affairs Office (202) 755-3680. Scientists and scientific groups should write David Gilman at NASA Headquarters, SC 7, Washington, DC 20546.

When Is a Quasar a Galaxy?

When the mysterious energetic quasars were first discovered in the mid-60s, their star-like appearance helped scientists distinguish them from galaxies, all of which have extended halos or spiral arms of stars and gas. But what else delineates the differences in quasars and galaxies? Are quasars intrinsically super-bright cores of galaxies, or another phenomenon altogether? (See "The Quasar Connection," ASTRONOMY, December 1979 and "Why All the Fuss about Quasars?", ASTRONOMY, October 1980.)

Over the past few years, several objects originally thought to be quasars have been reclassified as galaxies when extended halos were found around them. But now scientists have discovered a nebulosity in one of the "classical" quasars. The violent energetic behavior seen in this object, and thus in other quasars, could therefore indicate unusual galactic activity.

The quasar/galaxy is 3C-273, one of the better known and earliest discovered quasars. Dr. Susan Wyckoff, of Arizona State University, and her colleagues in England, Australia, Chile, and West Germany reported the discovery of 3C-273's nebulosity in a recent issue of the *Astrophysical Journal Letters*.

Using the 3.6-meter telescope at the European Space Observatory in Chile and the Anglo-Australian Telescope in Australia, they took a photograph of 3C-273 and analyzed its image with a digital scanning device. They electronically removed the well-known jet emanating from the quasar image, and then compared the remaining image to that of a star. Then they compared the point-like stellar image to that of 3C-273 and searched for any dim, hitherto undiscovered nebulosity around the quasar.

They found a weak halo extending apparently for 150,000 light-years from the core of 3C-273. To further show that the nebulosity was actually associated with 3C-273, they took spectra of the nebulosity and found it to have the same redshift ($z = 0.158$) as the core. Hence, the nebulosity is part of a faint underlying galactic halo and not some superimposed, unrelated galaxy.

With 3C-273 classified as a galaxy and not a quasar, astronomers must now understand how their prototype "quasar" makes sense as an active "galaxy." It now seems that quasars may be the most explosive — and hence interesting — phase of galactic evolution, and 3C-273 may represent a "missing link" between quasars and galaxies.

SS-433 May Explode

The strange binary star system SS-433 seems to be speeding up and, unless it drastically changes, the system could explode sometime within the next 50 years. That dramatic future for SS-433, perhaps one of the most perplexing oddities in the history of astronomy, is projected by two Ohio State University researchers, George Collins and Gerald Newsom.

SS-433 is a double stellar system some 10,000 light-years from Earth located in the constellation Aquila near the bright star Altair. (See "The Puzzle of SS-433," ASTRONOMY, July 1980.) With a magnitude of 14, it's about 2,000 times fainter than the faintest star visible to the naked eye. Like all binary star systems, SS-433 consists of two stars spinning around each other, held in check by their mutual gravity. This system is unique, however. SS-433 first came to public attention when it was found that the system had both blue-shifted and red-shifted lines in its spectrum at the same time. Furthermore, the two sets of shifted lines move, eventually changing places entirely.

Collins and Newsom suggest that one star may be a massive supergiant, perhaps 50 times the mass of the Sun, with a magnetic field several thousand times that of Earth. This strong field, which a normal star wouldn't have, spreads out as a disk around the star's middle. The smaller partner, they say, is probably a neutron star and is responsible for large emissions of X-rays as well as other forms of radiation.

"We suggest that the big star has a large magnetic field extending out a long way — perhaps several hundred times the distance from the Earth to the Sun (93,000,000 miles)," Collins says. "In the magnetic field, material ejected from the big star gets trapped and glows. That's what we think causes the changing spectrum."

Similar conditions have been seen by recent space probes around Jupiter, where high-speed particles are being accelerated by the planet's magnetic field to about one-quarter the speed of light. "If a planet can do that, think of what a giant star can do. Not only is it not farfetched, it may prove to be commonplace," he says. "It's just that the magneto-hydrodynamics needed to prove this are very, very difficult. If problems this complex could be solved, then the problem of thermonuclear fusion could have been solved 20 years ago."

When SS-433 was first studied several years ago, the shifting of the spectrum occurred every 167 days. What Collins and Newsom have found is a decrease in this period. "The system is changing very rapidly. This period has changed from 167 to 165 days, and then it dropped to 164 days. Now, it's about 162 days long," Collins says. "It's changing, getting shorter every day by about 15 minutes. Each period is shorter by 1.6 to 1.7 days."

The data showing the decrease have been available for more than a year, but no one really noticed it before, they say. "One member of the binary could be spinning down and wobbling faster like a top. That's perhaps the best explanation within the framework of our model."

At the present rate, the period will dwindle to nothing within 50 years. If the binary system is losing energy and collapsing, the period

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would continue to decrease, according to the researchers. If that happens, the two stars would eventually collide.

"No one knows what would happen if a binary system coalesces on a time scale of 50 years. It's unprecedented. Time scales for these events typically are millions to billions of years. Your chances of seeing this kind of event are very, very poor. That's what makes this so astounding," Collins says.

But both researchers point out another alternative to the proposed catastrophe — the large star may be spinning more and more slowly, a condition which also could account for the shorter period.

Collins is skeptical of the collapsing-system scenario. "I just don't think that we're that lucky." He suggests that this decreasing period may just be a "phase that the system goes through, possibly short-lived."

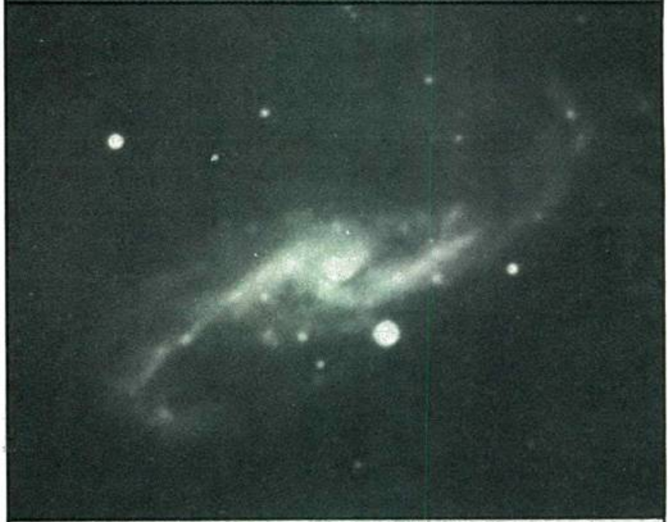
"But there's no question that this system is going to change its nature in our lifetime," they say. There is a way to decide between the two explanations for the decreasing period. Collins and Newsom are working on that problem now.

"I know that what we're proposing can be interpreted as farfetched but we're simply reporting data gathered from all over the world. It's not even our data so we can't be accused of rigging it," they explain.

"I'm a scientist. I have to let the chips fall where they may. And the information now says that, if the trend continues, this phase of the system could terminate in 50 years or less."

The findings were included in an announcement by the International Astronomical Union and in a presentation by Newsom to the Texas Symposium on Relativistic Astrophysics in December.

New Supernova



The new supernova in NGC-4536 was photographed on March 7 at the University of Texas McDonald Observatory with a 72-cm telescope. Photograph courtesy of McDonald Observatory.

Spotting Satellites — and More

The first in a series of new, highly sophisticated computer-driven telescopes for detecting man-made satellites has just been completed in California. The new system, called GEODSS, for Ground-Based Electro-Optical Deep Space Surveillance System, is being developed for the U.S. Air Force System Command's Electronic Systems Division by TRW, Inc.

This system of complex state-of-the-art telescopes, special slow-scan cameras, and computers will greatly increase United States capability to detect, track, and extract information on satellites orbiting above 3,000 miles. There is special interest in activity at the synchronous orbital range of 22,000 miles.

Five sites are planned to give the system global capability. Lt. Col. William C. Jeas, Air Force Program Manager, states, "The technological advances of GEODSS give it a key role in detecting and tracking deep space satellites. It significantly enhances our nation's military posture."

The system, which works only during hours of darkness, operates in a unique "step/stare" mode to detect moving satellites against an immense star field. The huge 3,200-pound telescopes are moved through a full 2-degree field of view and settled to within 1.5 arc-seconds within one second by a newly developed 17,000-pound mount. The telescopes use highly sensitive slow-scan electronic cameras.

To see satellites against the star background, the telescopes are driven at a sidereal rate which counters the Earth's rotation and fixes the star field. With the star images then appearing as fixed points, the camera snaps a series of electronic pictures which are stored in mini-computers and processed immediately to look for "moving targets," probably satellites. The system is capable of automatically detecting satellites in seconds and then moving on to process a new area of the sky.

The 40-inch main telescopes of GEODSS are capable of detecting satellites down to a visual magnitude of 16.4. Higher sensitivities up to magnitude 18.5 are possible in special "sensitive track" modes of operation. GEODSS is so sensitive it can detect an object the size of a soccer ball at 22,000 miles.

One advantage GEODSS has over its forebear, the U.S. Air Force Baker-Nunn System, is its ability to process enormous regions of the sky in a very short time. Baker-Nunn used film as its light-sensitive medium, and consequently required long processing delays. The two GEODSS main telescopes and cameras are capable of automatically processing 2400 square degrees of sky, or about 20 percent of the viewable region, per hour. The auxiliary telescope is capable of even higher rates, up to 15,000 square degrees per hour. These rates represent an enormous improvement of about 100 to 1 over previous capabilities.

The heart of the automatic processing is a computer program called ASTROSO (Adaptive Software To Recognize Orbiting Space Objects) developed to demonstrate the feasibility of the star cancellation system.

The system has evoked considerable excitement in the astronomical community as a possible powerful new tool for astronomical research. The system sees more stars in an hour (6,000,000) than have been cataloged throughout history. The satellite has excited the interest of University of Washington astronomer Bruce Margon who says, "The potential of GEODSS for conducting pure astronomical research as an adjunct to its primary function is enormous — far exceeding the capability of any existing system for some types of observations. Data on problems as diverse as the nature of quasars, pulsars, and stellar mass black holes could be available in profusion from a suitably instrumented system. The University of Washington, with TRW as its subcontractor, has proposed to the National Science Foundation a program to construct and install prototypes of the required auxiliary instrumentation, and plans to make the data available to the entire worldwide scientific community, on a non-interference basis with the basic Air Force Work."

Presently designated sites for the GEODSS System include: Taegu, Korea; Maui, Hawaii; and White Sands, New Mexico. East Atlantic and Middle East sites are presently being selected. White Sands is also the location of the Lincoln Laboratory Experimental Test Site, where major system elements were tested, and proof of concept was established, in the years prior to the GEODSS go-ahead.

A Simpler Origin of Life?

In a new theory about the chemical evolution of life, a NASA scientist proposes that simple self-replicating chemical systems rather than complex ones could have been the precursors of living cells more than 3.5 billion years ago.

The new theory, published in the latest issue of the *Journal of Molecular Evolution*, was developed by Dr. David White, Assistant Professor at the University of Santa Clara, California, and Research Associate in the Extraterrestrial Research Division at NASA's Ames Research Center, Mountain View, California.

White proposes that the first chemical ancestors of life were themselves "alive" only in the sense that they could reproduce themselves and may have been far simpler than previously believed.

The prevailing theory of the chemical evolution of life holds that natural energy, such as lightning, sunlight, and heat, interacted with the atmosphere, soils, and oceans of the primordial Earth. The continuous interaction and evolution over millions of years eventually produced complex chemical systems that could reproduce themselves and that led to the first living cells.

The problem lay in getting the right chemical building blocks together in the right place at the right time. The process that led to living cells is easier to explain, however, if the necessary components are simple and few in number.

According to White's theory, very simple self-replicating systems could have appeared very early in chemical evolution. A key to the theory — whether these simple molecules would be capable of reproducing themselves — has been demonstrated by Ames and University of Santa Clara researchers.

Experiments showed that under simulated primitive Earth conditions, a short chain of amino acid molecules can produce longer chains of another amino acid and still longer chains of a catalyst molecule. The catalyst molecule functions like an inefficient, primitive enzyme. It is the first such simple molecule to demonstrate the vital ability to catalyze (chemically facilitate) a reaction — an ability essential for life.

The "proto-enzyme catalyst," as it is called, was suggested by White's theory. Researchers looked for and found it, and White believes there are a number of other simple, short amino acid chain catalysts yet to be discovered.

The discovery of the catalyst molecule and its work is important, but it is not enough for the origin of a self-reproducing system of molecules. That requires nucleic acids as well as molecules in order to carry genetic information to the next generation.

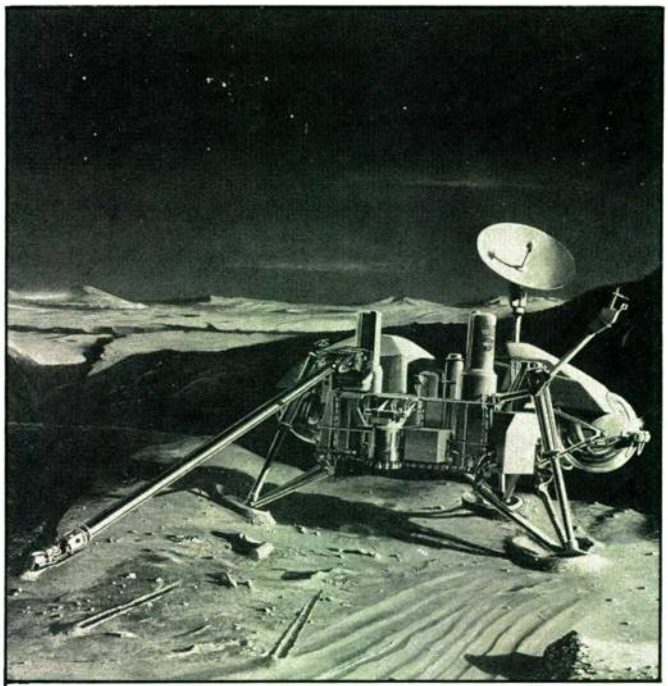
Computer modeling, based on known properties of molecules, showed that, in theory, a self-reproducing system could be amazingly simple. In principle, the simplest possible system would consist of two proto-enzyme amino acid chains. This assumes that molecules from which to build amino acids and nucleic acids were already present in the primordial environment, an assumption which has gained some support from laboratory simulation experiments.

In this theoretical system, the two short proto-enzyme amino acid chains would be able to synthesize themselves and two nucleic acid chains which, in turn, tell the amino acid chains how to make all four products of the system. This "four-component system" (the two amino acid chains plus the two nucleic acid chains) is theoretically able to make many more such systems from the stock of building blocks which are presumed to have existed in the primordial environment.

Just how the nucleic acids would specify the exact amino acid chains remains to be demonstrated, which is a problem for all such theories. One advantage of White's theory is that the accuracy of the specification process need not be very great.

"We may find that a four-component system is too simple," commented White. "We may have to look for more complexity to get realistic self-reproduction. However, the success of these first experiments suggests that simple catalytic processes may be common in nature. Besides, we have not been able to formulate any other way to get the whole thing started."

Researchers now plan an array of experiments using the most commonly found biological building blocks to look for other simple catalysts and for nucleic acid patterners. The goal is to discover whether self-reproducing molecules can organize themselves in laboratory experiments. Another advantage of White's theory is that it provides guidelines for the design of future experiments to test its predictions.



NASA's Thomas A. Mutch Memorial Station

The Viking Fund

A check for $60,000 was presented by the Viking Fund to NASA Administrator Dr. Robert A. Frosch on Wednesday, January 7, in ceremonies held at the National Air and Space Museum. The check represents money sent in from thousands of individuals throughout the country to support the continued operation of the Viking 1 Lander on Mars and scientific analysis of Viking data.

Following the Viking Fund presentation, Dr. Frosch unveiled a plaque commemorating Dr. Thomas A. Mutch, Office of Space Science Associate Administrator, who was lost in an accident while mountain climbing in the Himalayas this past October. The memorial plaque to Dr. Mutch is a stainless 8" x 10" plate etched with the following statement:

"Thomas A. Mutch
Memorial Station

Dedicated to the memory of Tim Mutch, whose imagination, verve and resolve contributed greatly to the exploration of the solar system."

The plaque is intended to be attached to the Viking 1 Lander on Mars, now renamed the Thomas A. Mutch Memorial Station.

The Viking Fund is a private organization under the auspices of the American Astronautical Society. Another $40,000 in private donations is expected.

Dr. Frosch said, "I wish to express my sincere thanks for your organization's generous show of support. As important as the money you have raised and are donating, is the expression of a deep and abiding commitment by many people to a strong and ongoing space effort."

NASA has designated July and August 1981, the fifth anniversaries of the Viking arrivals at Mars, as "Viking Fund Months." Acquisition by the NASA Deep Space Network of data transmitted by the Mutch Memorial Station during these months will be paid for with the fund's donation. As a result of the availability of this money to support the network, scientists will be able to reconstruct martian wind data gathered by Viking during a period of partial instrument failure. And, working with the U.S. Geological Survey, NASA will use Viking images to produce a global albedo map of the planet. A special issue of the *Journal of Geophysical Research* on the Mars Colloquium will be distributed to the planetary science community.

Dr. Frosch charged future administrators to determine an appropriate Mars return mission by which the plaque can be placed on the Viking 1 Lander. NASA has no current plans for a return mission to Mars, although several mission concepts are being studied.

ASTRONOMY REVIEWS

Amateur Astronomer's Handbook
J.B. Sidgwick
568 pages, hardbound, $24.95
Enslow Publishers (1980)

If you should happen to be observing the skies from the vicinity of Olifantsfontein, South Africa, and need the equivalent of the time-signal service of WWV, what frequency do you tune your radio to? When you rack an ocular out of focus and examine the shimmering concentric rings, just what are you seeing, and why? Exactly how does photographing a comet differ from photographing a galaxy? How do the Buchroeder and Dillsworth catadioptric systems compare with each other, and with other similar variations? Why, mathematically, does coma become a problem when aperture is large relative to focal length?

The revised fourth edition of Sidgwick's *Amateur Astronomer's Handbook* answers these questions and provides a veritable profusion of other specialized information.

"...this is neither a formal textbook designed for consecutive reading, nor, on the other hand, a narrowly practical manual of instruction. It is a reference handbook..."

Written in the spring of 1954, Sidgwick's words (taken from the preface) accurately describe a volume which in a quarter century has become a near-classic of great practical worth to astronomical observers.

This timely, modernized revision by James Muirden is not the book for someone who hasn't yet become acquainted with at least the rudiments of astronomy, nor will it help much in acquiring observational technique. For whom; then, is the book written?

Sidgwick gave the answer in the foreword to the first edition. He contended that once the initial spark of interest is struck, the typical beginner commences to read widely about astronomy and continues this until mere "armchair observing" no longer satisfies. Next, he buys a telescope to pursue things at first hand.

Then, says Sidgwick, the observer enters a stage of rather unmethodical observing which lasts for a year or so. (Some lose interest at this point — perhaps because what they see doesn't match the photos the books were full of.) But eventually many find their interest beginning to narrow and focusing on what becomes a favorite area: planets, nebulae, star clusters, or some such.

At this point, our hypothetical backyard astronomer may buy an instrument more appropriate to his evolved area of celestial concentration — say, a large aperture, low f/ratio scope for deep-sky stuff, or a long focus instrument for planet watching. This, according to Sidgwick, is the level of interest and expertise at which someone will find the *Handbook* of significant value.

It's authoritative: it covers equipment, photometry and photography, atmospheric influences on "seeing," time, accessories, instrumentation, mountings, and a world of information not easily available elsewhere. The *Handbook* is mainly a treatise on things an observer should know about the theoretical and instrumental aspects of astronomy.

In an amusing aside, Sidgwick wryly advises that carrots and cod liver oil (both of which contain vitamin A, which aids in dark sensitivity) might profitably become part of an observer's regular diet — especially comet-seekers. Regarding the light sensitivity of the human eye, the author says those with perfect — but not exceptional vision — can normally see 9 or 10 stars in the Pleiades. Morover, he claims that those with exceptional vision will detect 12 stars in the popular winter asterism.

Carrots and cod notwithstanding, Sidgwick's magnum opus is a tightly woven cornucopia of diagrams, formulas, line drawings, tables, and succinct writing that touches on most elements of modern amateur astronomy.

A notable feature of the book is that the effects of revision are not readily apparent unless a direct comparison is made to a previous edition. Considerable amounts of new material blend smoothly and comfortably with the original. James Muirden, the prolific British author of astronomy literature, has retained the compactly organized, logical structure of previous editions. He has excised much outmoded material and inserted fresh, technically accurate information. Throughout the deletions, additions, and rewritten sections, he has consistently adhered to the quality and flavor of the original.

The well-bound volume is divided into 41 chapters, or sections. At the beginning of each, before detailed treatment of the subject gets underway, what follows and how it relates to the topic under discussion is summarized.

You can dip into the *Amateur Astronomer's Handbook* from time to time as the need arises. Since it deals heavily in mathematically derived concepts, theory, fact, and fundamentals, it is less a browser's delight than many reference books. However, it shares a common characteristic with any dictionary, i.e., while you search for some particular bit of information, you often run across something else, equally interesting. (How often have you managed to look up just *one* item in an encyclopedia?)

Topics are treated with varying degrees of thoroughness, since the author's criteria for how deep to delve stem from his personal perception of just what an advanced amateur needs to know. Impressively, Sidgwick is often right on target.

The massive bibliography evidences an extensive literature search. Its voluminous number of entries — over 600 — has been organized into sections which coincide with the major divisions of the volume.

Although expensive, it's probably as complete for its intended audience as possible. The book is remarkable for its wide coverage, not for its relatively minor shortcomings that mainly involve unimportant typographical errors.

Sidgwick (now dead) would be pleased to know that nearly every experienced observer delving into this revised edition, would agree that it remains what the author intended it to be: a useful volume dealing more with the "why" rather than the "how" of amateur astronomy. *Gail O. Clark.*

The Physics-Astronomy Frontier
Fred Hoyle and Jayant Narlikar
483 pages, hardcover, $19.95
W.H. Freeman (1980)

The merging of physics and astronomy has galloped along ever since the convergence began in the late 19th century. Yet most astronomy textbooks, even those aimed at "science majors," place heavy stress on descriptive astronomy.

Interestingly, this one doesn't. Instead, Hoyle and Narlikar approach the subject directly through physics — they start off with space-time diagrams and quantum mechanics — but keep the mathematics to what should be "easily within the scope of anyone who has a strong high school background in science."

The Search for Life in the Universe
Donald Goldsmith & Tobias Owen
436 pages, paperback, $12.95
Benjamin/Cummings Pub. Co. (1980)

The Search for Life in the Universe is one of about 40 books currently in print which deal with extraterrestrial life, extraterrestrial intelligence and/or the search for either or both. It may be one of the most recent, but it is not one of the best.

Search is a textbook, as authors Goldsmith and Owen state clearly in the preface (the part of a book few people read). That's fine; but it is not a textbook of exobiology or planetary exploration, as its title might imply. It is, in fact, an astronomy text, to be used in short-short courses on the undergraduate college level for people who probably don't care too much for the subject but need to fulfill their science requirement. The "life in the universe" and "extraterrestrial intelligence" bit is the hook to draw in otherwise bored students.

The astronomy is good astronomy: both Goldsmith and Owen teach the subject. Owen is a member of the Voyager and Viking spacecraft mission teams; Goldsmith has worked as a consultant to Carl Sagan's *Cosmos* TV series and heads a company that produces educational materials — films, booklets and so forth — on astronomy. He's also the author of another text-anthology, *The Quest for Extraterrestrial Life.*

Search proceeds through five parts and 22 chapters to discuss the origin and evolution of the universe, galaxies, stars, and planets; the origin and evolution of life on our planet; the search for life on other planets and moons of the solar system; and the search for extraterrestrial intelligence. One chapter deals with the von Daniken and UFO-visitation theories. The last chapter asks the question, "Where is everybody?"

The content of the book is accurate and up-to-date. The writing is clear but "textbookish." The questions at the

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end of each chapter are irritating if you aren't reading the book as a text — and perhaps even if you are. The binding is unusually low in quality, but that's not something the authors have much control over.

Nevertheless, the book isn't the best of a large crop, and, at $12.95, it's very overpriced — even for a text. Better buys, for about the same money, would be Ian Ridpath's 1978 book *Worlds Beyond* and editor Carl Sagan's *Communication with Extraterrestrial Intelligence* published in 1973. Both are in print and available as paperbacks. *Joel Davis.*

Galaxies
Timothy Ferris
182 pages, hardcover, $75
Sierra Club Books (1980)

Galaxies is a visual and tactile feast. The size (13" x 14") and heft (5 lbs.) of the book does justice to its content as does the gloss of its enameled stock. You will find yourself checking each page for stray fingerprints and making your friends don gloves before even a casual browse.

Many of the photographs are familiar, but become more impressive when seen in this size and with this quality of reproduction. The volume features generous white space and room for text and illustrations to breathe. Diagrams are cleanly done and complement the flow of the text.

The book is structured as a galactic tour, a journey through our neighborhood nebulae and star clusters toward the core of the Milky Way.

From our home galaxy, we travel first to the Magellanic Clouds and our local galactic cluster, then on to larger clusters and superclusters toward the edge of the universe.

The variety of galactic forms are explored, diagramed, and beautifully photographed.

More than mere photo captions, the text of *Galaxies* is also a feast of words. Here's an appetizer:

"...the interstellar clouds at last fall away. Ahead lies the central region of the galaxy, an elliptical cosmos of stars glowing through the relatively unsullied spaces with fantastic clarity. The color of this great egg is that of a bloodied yolk, the red and orange of old stars that have been burning steadily for billions of years. Behind us, the inner portions of the dusky ring hang like the walls of a canyon; thousands of light-years down one wall we can discern the elbow joint where one spiral arm emerges from the central regions and begins a winding path that will eventually take it out past our Sun."

Imagine *that* image on a 13" x 14" page!

Mr. Ferris can also leaven his awe with droll humor:

"For almost every known ring galaxy, a companion galaxy may be found nearby, slinking away from the scene of the collision."

Such tidbits entertain as well as instruct, allowing even his final chapter on cosmology to be chewed on, if not swallowed.

The most indigestable element of this book is its price: $75 — about $12.50 a chapter.

However, you could skip a few sirloin steaks and eat peanut butter sandwiches for a month while enjoying the book. Just don't leave any crumbs between the nebulae.... *Bruce Bond.*

Fireballs, Meteors, & Meteorites
Harold R. Povenmire
215 pages, hardcover, $10.95
JSB Enterprises (1980)

Meteor watching means staying alert during those long dark hours after midnight — which is why it's such a popular group astronomical activity. Having two observers instead of only one will often increase the number seen more than twofold. Povenmire's book explains how to observe meteors, visually or with camera, in groups or singly.

Annual Review of Astronomy and Astrophysics
G. Burbidge, *et al.*, eds.
591 pages, hardcover, $20
Annual Reviews (1980)

Intended for the professional astronomer, who wants to survey what's happening in the field in general, and for the specialist, the 1980 *Annual Review of Astronomy and Astrophysics* prints 15 articles summarizing the "state of the art" of various astronomical problems. Topics include the masses of Cepheids, white dwarf stars, and formation of the terrestrial planets, to name a few.

RTMC 80
William A. Schramm, ed.
120 pages, paperback, $8
OCA Publications (1980)
[publisher's address: 2215 Martha Ave., Orange, CA 92667]

RTMC stands for "Riverside Telescope Makers Conference," and this is the reprint of the papers given at the 1980 meet. The 12 papers discuss such topics as cleaning optical surfaces with collodion, limitations to

More Inflation-Fighting Prices for 1981

Celestron

C-90 Spotting scope	$280
C-5 Base price	$599
C-8 Base price	$755
C-11 Base price	$2350
C-14 Base price	$4995

Meade

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Handbook of Soviet Manned Space Flight
Nicholas L. Johnson
461 pages; hardcover, $45; paperback, $25
American Astronautical Society (1980)

Like the author's companion volume on unmanned Soviet spaceprobes (see Astronomy Reviews, October 1980), this book is an attempt to get at the facts of their space program and provide a history of it.

Voyage to Jupiter
David Morrison & Jane Samz
199 pages, paperback, $7.50
NASA (1980)

The two Voyager encounters with Jupiter produced some of the most stunning images ever returned from space and delighted the imaginations of millions who thereby took a vicarious journey to the "king" of the planets.

Like a souvenir book of the trip, *Voyage to Jupiter* tells the story of the jovian missions: Pioneer 10 and 11's two reconnaissance looks and the two Voyagers themselves. Here also is the full scientific story, enhanced with many color photos, relating all that we've learned about the jovian system. And as a prospectus, the forthcoming Galileo mission (which has both atmospheric probe and an orbiter) is described in detail.

Lastly, the book includes the maps drawn by U.S. Geological Survey cartographers depicting the names and surface features for the four Galilean moons.

Order as NASA SP-439 from Superintendent of Documents, U.S. Government Printing Office, Washington DC 20402.

Spacetime, Geometry, Cosmology
William L. Burke
329 pages, hardcover, no price given
University Science Books (1980)

Intended for "the serious student who wants to be able to calculate in the standard cosmological models and to understand those calculations," this textbook is clearly not for the mathematically disinclined. Yet a student comfortable with a moderate amount of calculus should be able to follow along — even using it for self-study.

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Neutrinos, formerly thought to be massless, may in fact have a small mass. If true, this would be one of the most significant astronomical discoveries of this century.

the invisible universe

by Adrian Melott

All we see around us — from roses and rocks to planets, stars, and galaxies — may be nothing but a trace contaminant in a vast sea of particles called neutrinos. Neutrinos may, in fact, be most of the matter in our universe — even though neutrinos pass through us, through the Earth, and through everything, virtually without effect. Indeed, our whole notion of what makes up the universe — and what will happen to it — suddenly seems open to drastic revision.

How has such an important discovery escaped scientists for so long? Part of it is that neutrinos hardly interact with other matter. Part of it is that neutrinos are the tiniest particles we know about. And part of it is that only recently — and only through exploring matter on the grand scale of clusters of galaxies and the miniscule scale of bits of atoms — have we detected the far-reaching effects of neutrinos.

A "Ghost" in the House of Physics

To understand how neutrinos fit in and behave, we must trace a bit of their history. Toward the end of the nineteenth century, physicists discovered radioactivity. Certain substances found in nature such as uranium and radium emitted mysterious "rays" that, among other things, fogged photographic films kept secure from light.

As scientists unraveled the mystery of radioactivity, they discovered that the "rays" were produced when the nuclei of atoms changed form. In the first third of this century, physicists identified the three basic kinds of particles that combine to make up atoms.

Every atom, they found, has a heavy central portion — a nucleus — surrounded by a cloud of electrons. The nucleus can be pictured as composed of individual neutrons and protons. Some neutron/proton combinations are stable, but others are not — like a boulder rolling down a mountainside, they spontaneously seek to reach a more stable configuration.

In their research on radioactivity, scientists uncovered three kinds of "rays." Rather arbitrarily, they called them alpha, beta, and gamma rays. It was the attempt to understand *beta decay* that led to the discovery of the neutrino. Let us examine it more closely.

In beta decay, a neutron converts itself into a proton by emitting a beta ray. Since a neutron has no electric charge, beta rays had to have a negative charge (to cancel that of the new proton) for the reaction to happen. Beta rays turned out to be ordinary electrons (which do have a negative charge) moving at high speed.

An example of beta decay is that of tritium, an isotope of hydrogen. Tritium nuclei contain a proton and two neutrons. Since the neutron has no electric charge, it does not affect the chemical properties of this "heavy" hydrogen atom very much — it just makes it heavier.

But the "proton + 2 neutrons" nucleus is unstable and eventually turns itself into a "2 protons + 1 neutron" nucleus. Because it has two protons, the nucleus is a kind of helium. The experimenters observed beta particles, saw that the nuclei changed, and began to understand beta decay. Soon, however, a new problem emerged.

The "Little Neutral One"

Electrical charge is conserved in the beta decay process. We also know that energy must be conserved — that is, the total energy of all the components before and after any physical process must remain the same. However, the sum of the energies observed after the process was less than that observed before. Physics was faced with a crisis. In 1930, Wolfgang Pauli proposed the simplest explanation: a tiny, unobserved particle carried off the missing quantities and thus "rescued" the time-honored conservation laws. Enrico Fermi named Pauli's proposed particle the *neutrino*, meaning "little neutral one," and calculated its properties. (Great insights in science often result from applying the maxim that the simplest explanation is best — an approach credited to medieval philosopher William of Ockham and called "Ockham's Razor.")

We have since learned that the neutrino is also needed to account for conservation of angular momentum and "lepton number" in beta decay. The conservation of lepton number further requires that in beta decay an antineutrino, rather than a neutrino, be emitted. An antineutrino is identical to a neutrino, except for the reversal of certain properties.

Though neutrinos had been suggested, they weren't detected for many more years. This is due to the most outstanding characteristic of the neutrino: it has virtually no effect on ordinary matter, passing through it more easily than light through a windowpane. A neutrino could, for example, pass through a sheet of lead as thick as from here to Pluto and back with less than a 50-50 chance of being disturbed!

The surprise, therefore, is not that it took physicists a long time to detect neutrinos and prove their existence, but that they can be detected at all. If a very intense beam of neutrinos is sent through a lot of material, eventually a nuclear reaction will result. That wait may be long, though: as each neutrino passes a nucleus in the target material, it has roughly one chance in 10^{38} of interacting with that nucleus. Finally, in 1956, Frederick Reines and the late Clyde L. Cowan experimentally confirmed the existence of neutrinos.

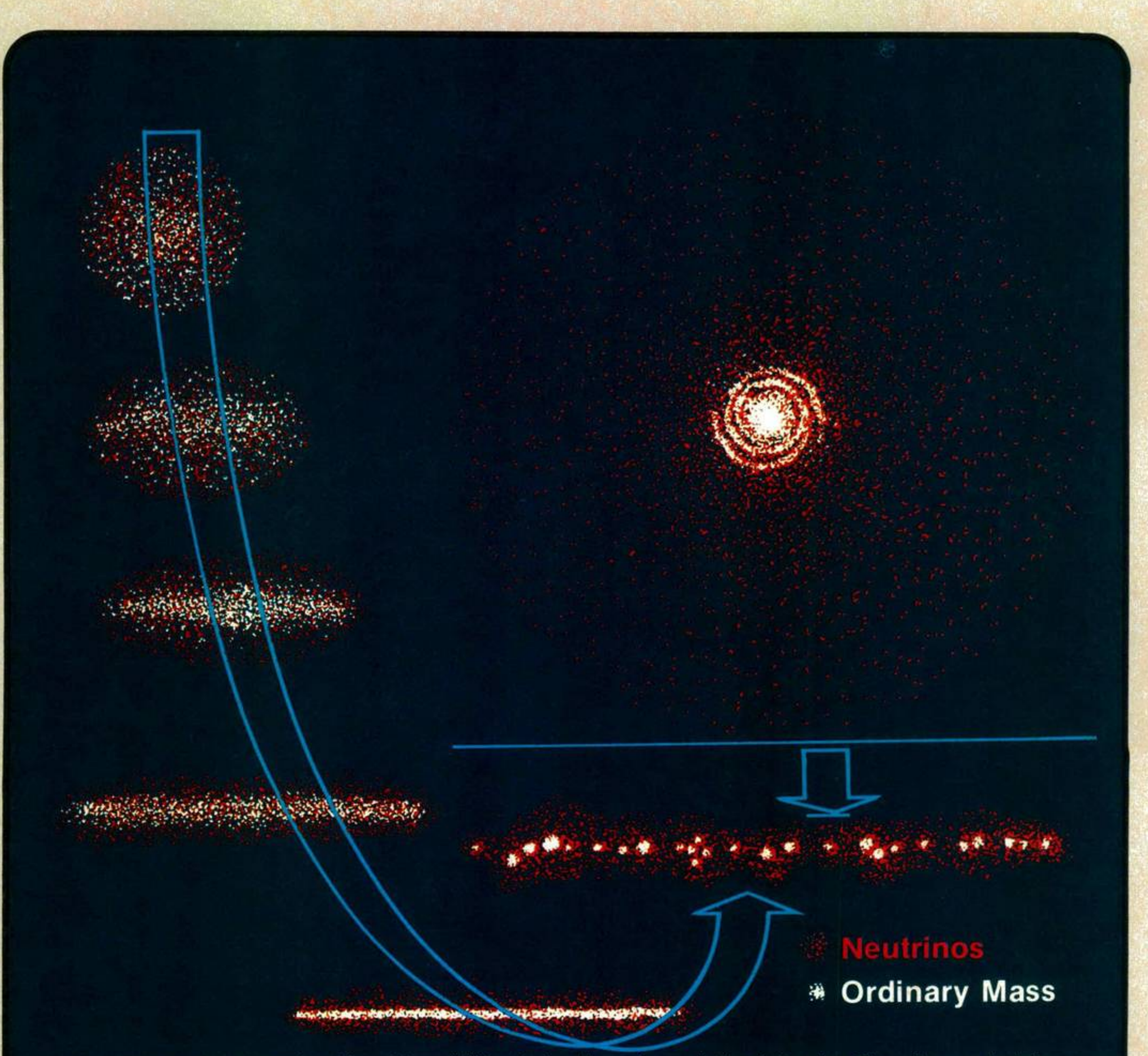
Neutrinos made news again about a decade later. Astrophysicists had developed a very coherent theory of how stars use nuclear reactions to provide the energy they emit as starlight. In this process, called *nuclear fusion*, small nuclei merge to form larger ones, with a great deal of energy given off. Fusion in the Sun produces large numbers of neutrinos — at least according to the calculations. Then Raymond Davis Jr. set up a neutrino detection experiment deep in a mine to detect solar neutrinos and test the astrophysical theories. After years of refinement, far fewer neutrinos have been detected than were expected — in fact, only about a third to a half of what there ought to be. All sorts of explanations were advanced for these results, but the neutrino problem remained intractable.

Will the Real Neutrino Please Stand Up?

The solar crisis may now be ending, with all sorts of implications for cosmology. In early 1980, Reines, Henry Sobel, and E. Pasierb announced the discovery of neutrino oscillations.

It seems that a neutrino is a mixture of "states," changing its identity as it moves along. As often happens in modern physics, especially in quantum physics, the behavior of the natural world comes to resemble a dream world: we are here reminded of the croquet balls in Lewis Carroll's *Through The Looking Glass* which, when struck, turn into hedgehogs, obediently run through the hoops,

M-81 is a spiral galaxy not unlike our own Milky Way. Such galaxies may be surrounded by invisible massive halos which could outweigh the visible matter in the universe by a factor of ten. Neutrinos could be the "missing matter" these halos are composed of. Photo courtesy of Kitt Peak National Observatory.



A huge mixture of matter and neutrinos (above left) begins to collapse by gravitational attraction. The collapse, calculations show, should begin to expand laterally. Such a process has been shown to lead to fragmentation of the "pancake," with individual clumps collapsing into galaxies and clusters. The neutrinos also collapse, forming massive halos much larger than the individual galaxies, but some neutrinos remain "free," and are not clumped at all.

and then resume their croquet ball identity.

Reines's experiment indicates that neutrinos produced in a nuclear reactor change their state as they travel away from the reactor. If the same effect operates in neutrinos from the Sun, then only some fraction will cause the nuclear reaction which signals their presence in Raymond Davis's neutrino detector. Therefore, we would expect an experimental result smaller than that previously predicted.

To understand the oscillations, we must recall that waves are associated with all matter. Everything has both wave and particle aspects, and what we observe depends on the size of object as well as the way we observe it. The frequency of these waves depends partly on the mass of the object.

Neutrino oscillations, therefore, imply neutrino mass. But all previous data were consistent with the neutrino having no mass at all! The neutrino mass may be only very slight, but it is terribly significant. Immense numbers of neutrinos have poured into the universe from atomic reactions since the very beginning of time. They should now number more than atoms in the universe — all invisible, all virtually not interacting with matter except for one very weak interaction: gravity. Even if neutrinos have a minute mass, they could weigh many times more than all the rest of the matter in the universe. Neutrinos might be the dominant material of the universe, overwhelming virtually everything else, yet hardly detectable.

While the experiments indicating an oscillation of neutrino types are difficult, uncertain, and controversial, recent results from the Soviet Union corroborate the original work. Experiments conducted at the Institute of Theoretical and Experimental Physics indicate a mass for the neutrino by measuring the tiny amount of energy the neutrino's mass robs from beta decay — around 35 electron volts. An electron volt is a particle physicist's unit of mass/energy, and is an incredibly small unit. Hydrogen atoms, the lightest atoms, weigh about a billion electron volts. An electron, the lightest previously known subatomic particle that has mass, weighs about 500,000 electron volts. It takes about as many electron volts of mass to make up an aspirin tablet as it would aspirin-tablet-masses to make up the Sun. So it's obvious why the neutrino mass evaded detection for so long.

Experiments which suggest neutrino mass are extremely difficult and liable to error. At present, for example, we think there are three different kinds of neutrinos, and each may differ in mass. The experimental results are still controversial among physicists, and are likely to remain so for a long time. But the potential impact of this tiny mass on astrophysics and cosmology is so great that we have only begun working out its implications.

Are Neutrinos the "Missing Mass"?

Although neutrinos are very light, they may collectively solve the biggest problem in modern cosmology — biggest both in the sense of requiring the largest amount of "stuff," as well as having the greatest impact on our view of the behavior of the whole universe — the "missing mass" problem. (See "Brown Dwarfs and Black Holes," ASTRONOMY, April 1978.)

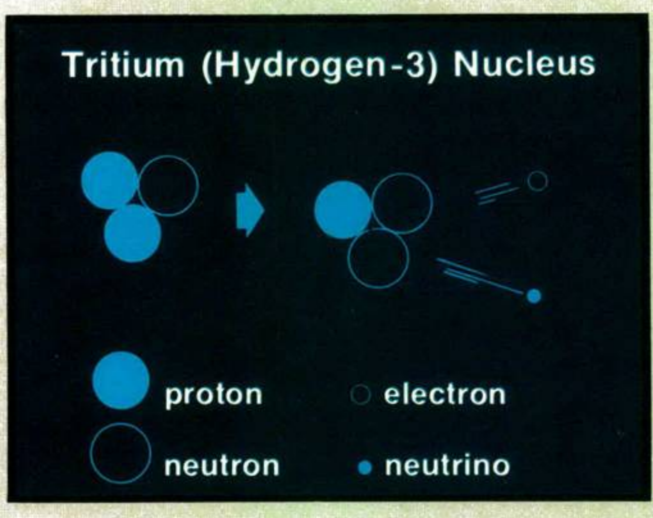
The problem is really a "missing light" problem. When we weigh galaxies, there seems to be matter which neither emits light like stars, nor absorbs it like gas and dust clouds. It therefore cannot be seen. However, we can deduce its existence by applying the laws of motion to objects seen orbiting around spiral galaxies like our own.

Newton's and Kepler's laws of motion, now hundreds of years old, tell us that the velocity of an object in a stable orbit around a central mass is slower the farther it is from that mass. When we measure the orbital velocity of matter orbiting the galaxy, we find that it stays about the same as we move away from the visible disk. This indicates that there is more mass surrounding the galaxy — mass we cannot see. There are indications that it extends in all directions as far as ten times the visible diameter of the galaxy, and that this invisible "halo" may be as much as ten times more massive than the galaxy itself.

The same problem appears when we determine the mass of groups and clusters of galaxies — and, in fact, it's even worse. We can measure the velocity galaxies have in such groups, and check this against the gravitational force that binds them together. The result is quite disparate: it seems the galaxies should have long ago flown away from each other, dissipating the cluster, unless some unseen material were providing much more mass.

On a still larger scale, even superclusters (clusters of clusters of galaxies) all show excessive velocities for their visible masses. Superclusters extend over distances of up to 100 million light-years, and have the mass of ten thousand trillion suns. Superclustering can be seen by looking at maps of the large-scale distribution of galaxies in the sky, and indeed superclusters seem to be the largest structures in the universe. At larger scales, there is a smooth distribution of visible matter.

Since the missing mass problem has been around for a while, a variety of ideas has been advanced to account for it. The most stringent requirement such material must meet is that we cannot easily observe its presence — a truly stringent condition. It rules out, for example, any known form of gas.



The tritium nucleus emits an electron and an antineutrino, and becomes a kind of helium nucleus. Early experimenters observed the electron, but the neutrino escaped detection for decades.

Stars are very common — how about some exotic type of star? It certainly is possible: very large stars, formed early in the history of the universe, would have burned out quickly, leaving dense dwarf stars, neutron stars, or black holes as remnants. All of these could easily escape detection. Or perhaps very small stars, called "brown dwarfs," that are very long-lived and burn very dimly. In fact, we expect that a star less than one-tenth the mass of the Sun would never begin shining at all. In a sense we may think of the planet Jupiter, one-hundredth the mass of the Sun, as a mini-star that never got started. Could the galaxies be surrounded with trillions of Jupiters?

These objects all seem quite reasonable candidates for halo material. However, they do not fit existing theories without substantial modification. Star formation would have to favor very much larger or smaller stars than it appears to favor now, but this may not be unreasonable since conditions in the early universe were quite different from conditions at present. There is, however, a more difficult problem: careful calculations indicate that if there were enough normal matter around to make up the missing mass, the amount of helium produced in the early universe shortly after the Big Bang would be greater than we observe today. We must stretch our picture of nature to accommodate such hypotheses, and this strains existing theories in physics and astronomy that already work well.

But if it turns out neutrinos do in fact have a small mass, we have a natural explanation — one that would make William of Ockham happy. Its naturalness lies in the fact that we can calculate how many neutrinos would have been present in the hot fireball of the early universe soon after the Big Bang. As the universe freely expanded, the neutrinos spread out just like the visible components of the

universe. Today there would be, on the average, about 120 of each of the three varieties of neutrino per cubic centimeter throughout the universe.

We can also calculate other neutrino parameters. The expansion of the universe has slowed the objects in it. The present speed of the neutrinos depends on their mass. If we use the 35 electron volt value, we find that their present velocity, assuming free expansion, would be a couple of kilometers per second. This may seem fast, but it is very slow by cosmic standards.

In fact, the force of gravity would have caused them to fall into "lumps" as they slowed down. The lumps would consist mainly of neutrinos, but would also contain a trace of ordinary matter. Calculations show that the neutrino lumps would have about the mass of a supercluster, the largest observed structure in our universe — a sign we may be on the right track.

Let's follow the collapse of one such lump. While we may assume it begins roughly spherical, it's unlikely to be perfectly so. It would probably be smaller along some axis. The collapse would proceed more rapidly along the short axis, so this region would "pancake." The neutrinos would fly right through the "pancake," but the hydrogen and other atoms would collide, and thereby dissipate their energy. The gas would then cool, subdividing further into galaxy-sized fragments. As these fragments cooled and formed galaxies, they would capture some of the neutrinos in their neighborhood. Alternatively, neutrino clumps may form, into which normal gas could fall, forming a galaxy at the center.

Among the bonuses neutrinos provide as a solution to the missing mass problem is a natural explanation of the fact that the problem is greater on larger scales. As we look at bigger and bigger chunks of the universe, the ratio of nonluminous matter to stars seems to increase dramatically. This tells us that while the "normal" matter is clumpy, the dark matter of the missing mass is more evenly distributed. Because they have no way to lose energy easily, neutrinos behave in just this way. They can't settle down into little clumps — only loose masses.

Because of the difficulty in weighing neutrinos in particle physics, we can try to weigh them using the galaxies. So supposing that neutrinos really are galactic halo material, we can set a lower limit on their mass. Since neutrinos belong to a class of particles called fermions which avoid being crowded together, there are specific limits on how many can be put into a certain amount of space. Since we know what density of matter we need in order to account for the orbits of material near galaxies, we can calculate that each neutrino must weigh at least ten electron volts — not far from the Soviet results.

If we can weigh them, can we also test the idea that neutrinos are present in large numbers? If neutrinos are the galactic halo material and even just slightly unstable, we might see a faint glow of ultraviolet light from their decay. If the theory proves good, you can be sure some experimenter will try to measure it soon. Of course, if neutrinos are the halo material, there must be many more of them "locally" than on the average through the universe — after all, we do live in a galaxy! What is the number? It turns out there would be 10 to 100 million neutrinos per cubic centimeter all around us, moving at about 300 kilometers per second. Yet it will still be very hard to find any possible effect. Nobel laureate Steven Weinberg has suggested that the presence of so many neutrinos may have a barely detectable effect on beta decay, when the decay takes place by absorbing a neutrino from the local neutrino background rather than by emitting an antineutrino. Clearly, we expect more experiments on neutrino oscillations and direct attempts at mass measurement.

The Ultimate Fate of the Universe

When Einstein developed his General Theory of Relativity early in this century, he was surprised and disturbed to see that it described an expanding (or contracting) universe. Not long thereafter, astronomer Edwin Hubble confirmed that indeed, on the average, the galaxies are moving away from each other. This overall expansion almost certainly results from the origin of the universe in a Big Bang ten to twenty billion years ago.

The future of this expansion depends on the average density of the universe. The gravitational pull objects in the universe have for each other slows the expansion. If there is enough mass in the universe, in fact, the expansion will stop and then reverse. The amount necessary to *just* stop the expansion is called *critical density*. Now, visible matter supplies about one-hundredth critical density. If this were the only matter, the universe would continue to expand forever, slowed only slightly. This scenario is called an "open" universe.

If the neutrinos are the missing mass material, we know they must add a great deal of mass to what we can see. The number of neutrinos calculated to be left over from the early universe, combined with the best mass we know for the neutrino, give us the total mass of the neutrinos. From the best estimates we have of these quantities, it is quite likely that the neutrinos are very significant. For example, assuming that there are three kinds of neutrinos with an average mass of 30 electron volts each averaging 120 per cubic centimeter throughout the universe, neutrinos should outweigh normal matter by 100 times. This means the density of the universe is equal to or greater than the critical density. If this is the case, the universe will eventually slow down, stop, then fall back together in a "Big Crunch," ending what started with the Big Bang.

The Coma Cluster is a giant aggregation of galaxies, much larger than our own Local Group. Such clusters would fly apart due to the motions of the galaxies within — unless some unseen matter binds them together gravitationally. Photo courtesy of Kitt Peak National Observatory.

Adrian Melott is an astrophysicist on the staff of the Center for Theoretical Physics at the University of Texas in Austin, and has been working on the cosmological implications of neutrino mass. The financial support of the center helped make this work possible.

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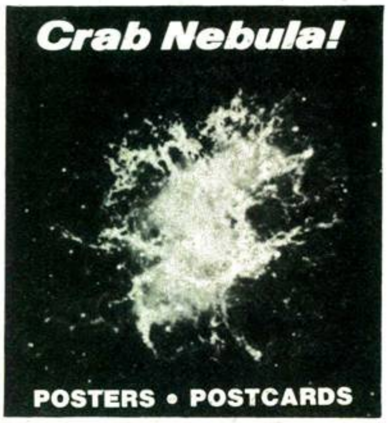

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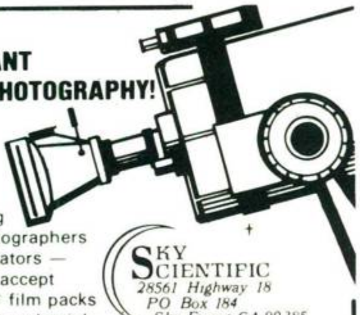

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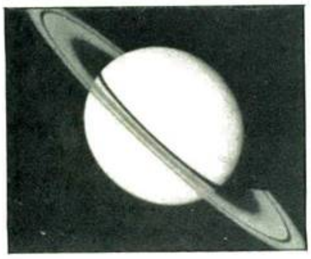

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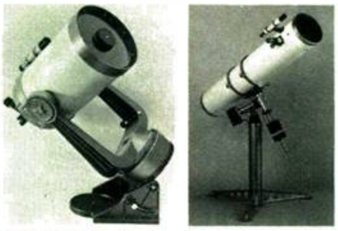

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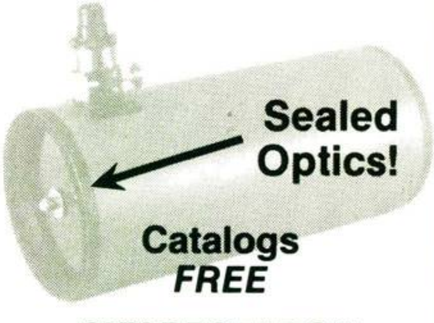

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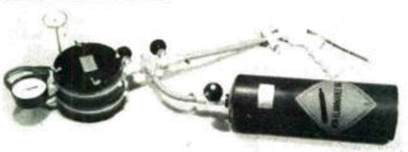

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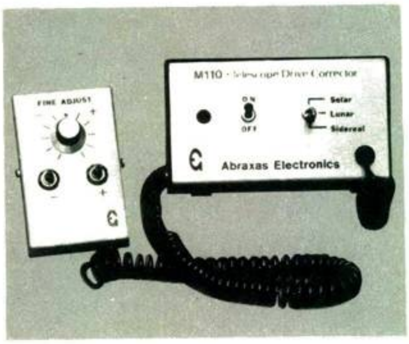

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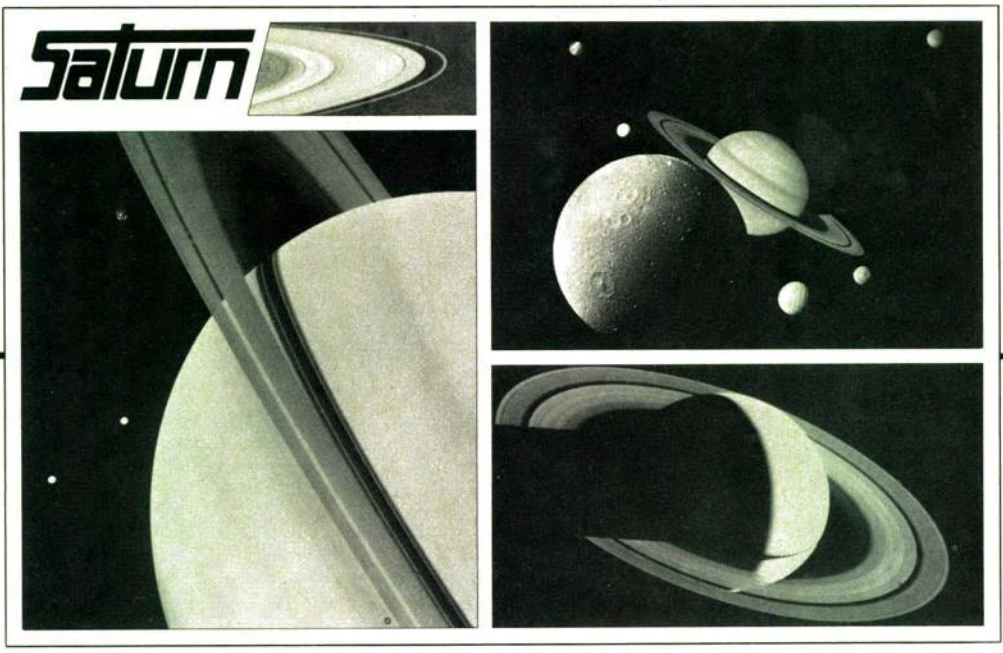

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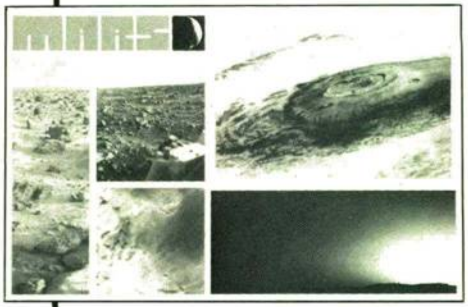
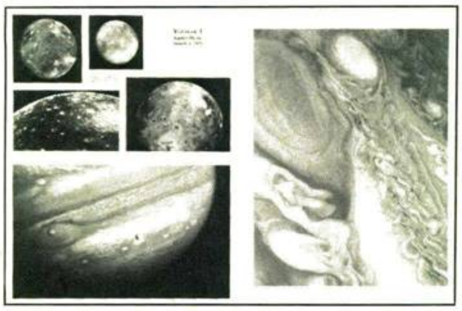
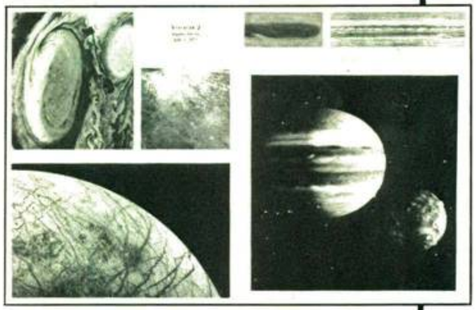
The Planets



MARS. 15 miles high by 400 wide, Olympus Mons dominates this dramatic poster, with wispy clouds, snow on the surface, rust-red rocks and extraterrestrial sunset.



JUPITER 1. Images from Voyager 1 of the Red Spot, floating satellites against the planet and close-ups of the fabulous Galilean moons.



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close-up on ursa minor/draco

through the eyepiece

The prime events for solar system observers this month are an excellent elongation of Mercury, a substantial meteor shower, and Uranus' arrival at opposition.

Mercury

The best apparition of Mercury this year will happen in the latter half of May and the first week of June. The planet will rise swiftly out of the sunset glow evening by evening, and you should start seeing it low in the west-northwest soon after the 7th.

Greatest elongation (23° east of the Sun) comes on the 27th at 4h UT, but greatest *elevation* (11°, 45 minutes after sunset) happens on the evenings of May 23 to 25. Forty-five minutes after sunset from May 15 through 31 inclusive, the planet will be at least 9° high. This provides telescope users with their best chance to find, observe, and follow the elusive innermost planet.

Mercury measures 5.7 arc-seconds on the 10th, and will nearly double that apparent size by the end of May. From a gibbous phase (82% lit) on the 10th, it will slender down to a crescent less than 28% lit on the 31st.

Don't miss it...it's not visible that often.

Venus

Venus, too, is emerging from the Sun's light into the evening sky, but its progress is much slower. Invisible after sunset on May 1st, it will be only a little more then 3° high at month's end. (Next month we'll run a diagram showing its motion in the evening sky for the rest of the year.)

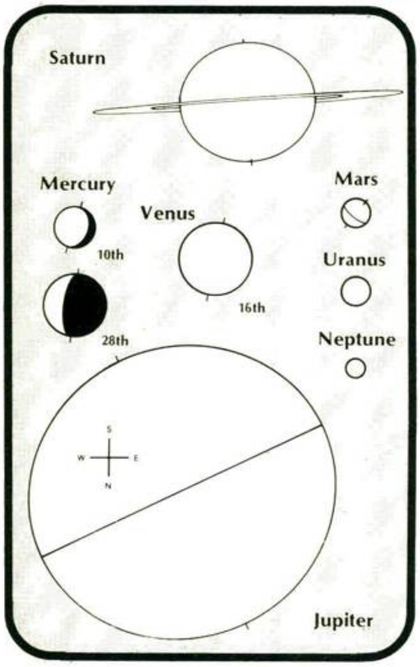
Arms, dust lanes, and a hint of a bar show beautifully in Martin Germano's photograph of NGC-2903, a type Sc spiral galaxy in Leo. He used an 8-inch f/10 Schmidt-Cassegrain and a 50-minute exposure on 103a-F spectroscopic film. North lies at upper left. This is the "Best Astro-Photo" award winner for May.

Mars

The red planet remains out of sight for all of May. No great loss, though — with its apparent diameter a meager 3.9" of arc, you wouldn't see too much anyway.

Asteroids

1 Ceres (magnitude 8.1) is in eastern Gemini at the beginning of May and will move into central Cancer by the end. Its positions:



10th: 8h 08m 13s, +28° 54.8′
20th: 8h 23m 32s, +27° 59.4′

Ceres sets around 1 a.m. local daylight time at mid-month.

2 Pallas (8.9) passes just to the north of Alnilam (Epsilon [ε] Orionis) in late May, but will be too close to the Sun to be seen at all this month.

3 Juno (10.1) is retrograding in central Virgo during May to the west of the 4.3 magnitude star, Tau (τ) Virginis. Positions:

10th: 13h 52m 45s, +1° 44.7′
20th: 13h 46m 40s, +2° 17.3′

At mid-month, Juno is setting just about when twilight begins to lighten the sky.

4 Vesta (7.3) is continuing its retrograde loop around Algieba (Gamma [γ] Leonis). On the 12th, Vesta will approach its closest, being 49′ of arc to the southwest of the star. Positions:

10th: 10h 15m 15s, +19° 31.8′
20th: 10h 23m 47s, +18° 22.2′

Vesta sets at about 2:30 a.m. local daylight time on the 15th. (All asteroid positions are in apparent coordinates.)

Jupiter

Its apparent size shrunk to about 40" of arc from its opposition maximum of 44", Jupiter is still a fine sight in a telescope. Additionally, it's a comfortably placed object in the evening sky, transiting just about when the sky becomes fully dark.

Saturn

Only a few degrees from Jupiter, Saturn shares its easy visibility — despite being nearly three magnitudes fainter.

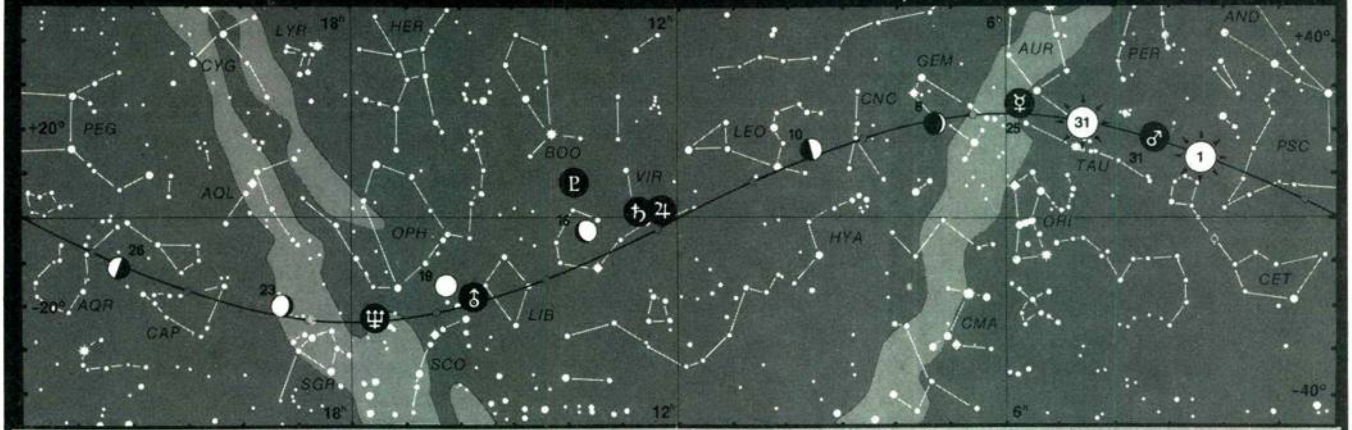
Because it's twice as far away as Jupiter, Saturn's apparent size doesn't dwindle as fast as Jupiter's does after opposition. It's less than a second of arc smaller than it was two months ago. The rings are now tipped about 4° 15′ to our line of sight and appear like a thin streak (3" of arc wide and 42" of arc long) across its oblate disk.

Titan, Saturn's biggest and brightest moon, will be at eastern elongation (distance: 3′ 6") on May 2 at 1:30 UT and May 17 at 23:30 UT.

Uranus

1981 marks the 200th anniversary of William Herschel's discovery of Uranus. On the 19th of this month (at 4h UT) it comes to opposition, just 42′ of arc to the east of 4.7 magnitude Kappa (κ) Librae. (Closest approach to the star is on June 3rd.)

planetary data may 1981


LYR
18h
HER
12h
6h
AND
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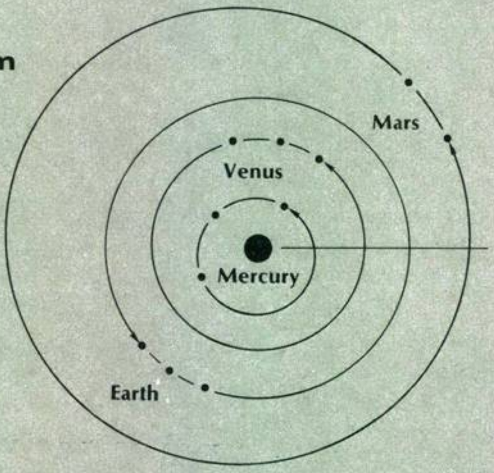
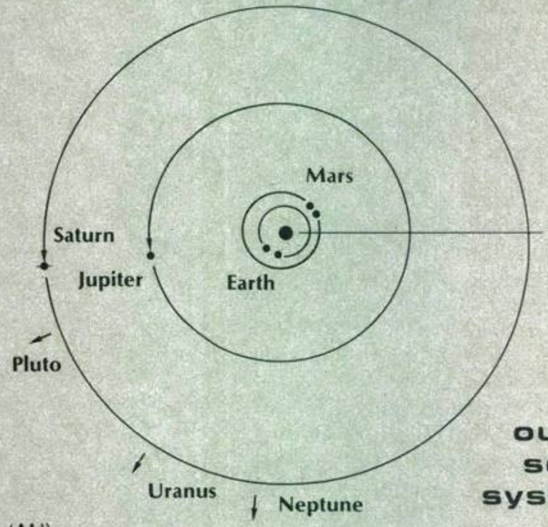
inner solar system


Mars
Venus
Mercury
Earth


Mars
Saturn
Jupiter
Earth
Pluto
Uranus
Neptune

outer solar system

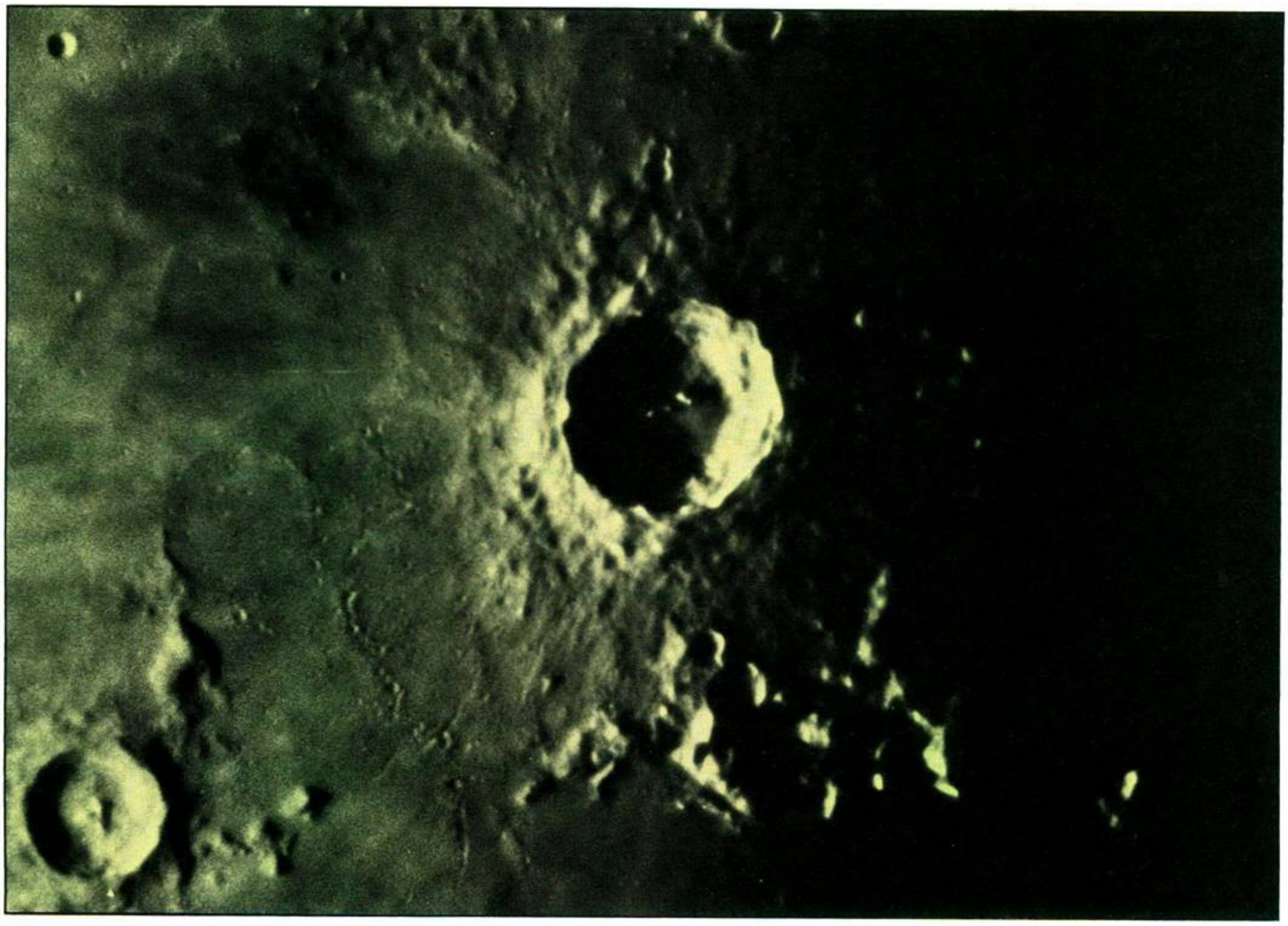
		Date	Mag.	Angular Size	% Illum.	Distance (AU) from: Earth	Distance (AU) from: Sun	Longitude: Heliocentric	Longitude: Ecliptic	R.A. (1981.4)	Dec
Sun		1	-26.7	31.8′	—	1.01	—	—	40°32.4′	2h 32.4m	+14°58.9′
		15	-26.7	31.7′	—	1.01	—	—	54°05.2′	3h 26.8m	+18°47.5′
		31	-26.7	31.6′	—	1.01	—	—	69°27.9′	4h 31.1m	+21°52.1′
Mercury	☿	1	-1.7	5.1″	99%	1.31	0.31	57°15.8′	44°01.2′	2h 47.6m	+16°25.4′
		15	-0.4	6.2″	68%	1.08	0.34	141°21.5′	71°43.7′	4h 41.8m	+24°26.3′
		31	+1.0	8.8″	29%	0.76	0.43	207°10.0′	91°22.2′	6h 07.9m	+24°51.0′
Venus	♀	10	-3.4	9.9″	99%	1.70	0.72	69°44.3′	57°19.9′	3h 42.1m	+19°29.7′
		31	-3.3	10.1″	97%	1.66	0.72	103°39.2′	83°07.1′	5h 31.7m	+23°57.2′
Mars	♂	15	+1.5	3.9″	100%	2.44	1.40	1°15.2′	44°11.8′	2h 48.9m	+16°01.1′
Jupiter	♃	15	-2.0	41.1″	100%	4.79	5.45	189°15.3′	180°16.1′	12h 04.9m	+1°05.4′
Saturn	♄	15	+1.0	18.7″	100%	8.90	9.57	188°03.8′	182°56.4′	12h 16.5m	+1°01.6′
Uranus	⛢	15	+5.8	3.9″	100%	17.80	18.81	238°03.2′	237°49.7′	15h 44.3m	-19°33.5′
Neptune	♆	15	+7.7	2.5″	100%	29.40	30.28	263°18.2′	263°46.2′	17h 35.3m	-21°57.3′
Pluto	♇	15	+13.9	—	100%	29.23	30.05	203°11.5′	201°45.1′	13h 46.4m	+7°54.0′

moon data

New Moon	May 4 at 04:19
First Quarter	May 10 at 22:22
Full Moon	May 19 at 00:04
Last Quarter	May 26 at 21:00
New Moon	June 2 at 11:32
First Quarter	June 9 at 11:33
Perigee: May 4 at 5h	357,026 km
Apogee: May 17 at 18h	406,393 km

universal time

Astronomers the world over use an unambiguous system of time reckoning — Universal Time (UT) — based on a 24 hour clock. Times given in Through the Eyepiece are UT unless noted otherwise. To convert UT into your local daylight time, subtract the following number of hours for each time zone: EDT, 4; CDT, 5; MDT, 6; PDT, 7; Alaska, 9. For example, if an event is to happen at 03:00 hours UT on June 7, then EDT for the event is 11 p.m., June 6. Likewise, 03:00 UT on September 2 becomes, in PDT, 8 p.m., September 1.



The early morning Sun has risen high enough to light about half the floor of Copernicus crater and touch the tips of its central peaks, while bringing out relief in the ramparts of hummocky ejecta surrounding the crater. Photographer Bill Wilkinson used a 6-inch Maksutov at f/120 and a one-second exposure on Tri-X.

Uranus is so distant (17.80 astronomical units, or 148.1 light-minutes, on the 19th), that its greenish-grey disk will be only 3.9″ of arc across. Its brightness, magnitude +5.8, puts it just within the range of unassisted eyesight, but to see it that way, you'll need superbly transparent skies and have to know just exactly where to look.

Neptune

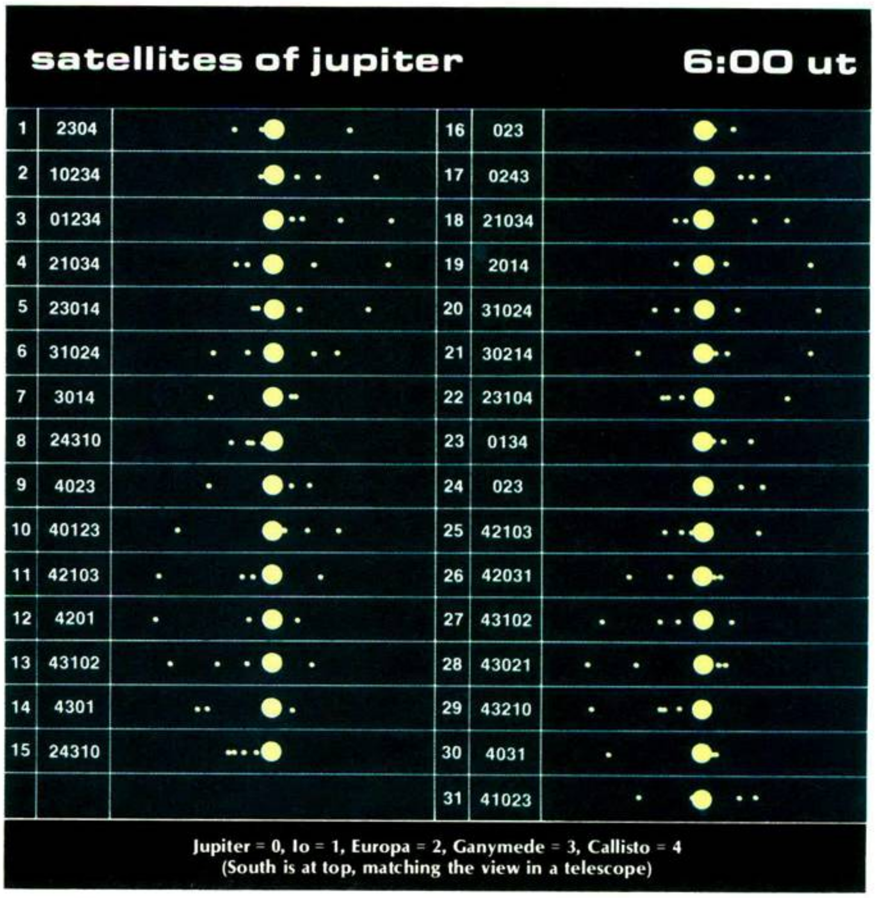
Neptune lies in the star-clutter of southern Ophiuchus, on the edge of the Milky Way. During May, its motion will be 40′ of arc (2m 40s of right ascension) almost due west.

At 7:41 UT on May 15, it will pass south of SAO 185543, "missing" the 9.2 magnitude star by about 20 seconds of arc. A little later, on the 25th at 21:53 UT, Neptune will pass 5.8′ north of 6.6 magnitude 52 Ophiuchi.

Meteors

The Eta (η) Aquarid shower, known for its bright, fast meteors that leave longish trails, will peak on May 4 — the night of May 3 to 4 in North America.

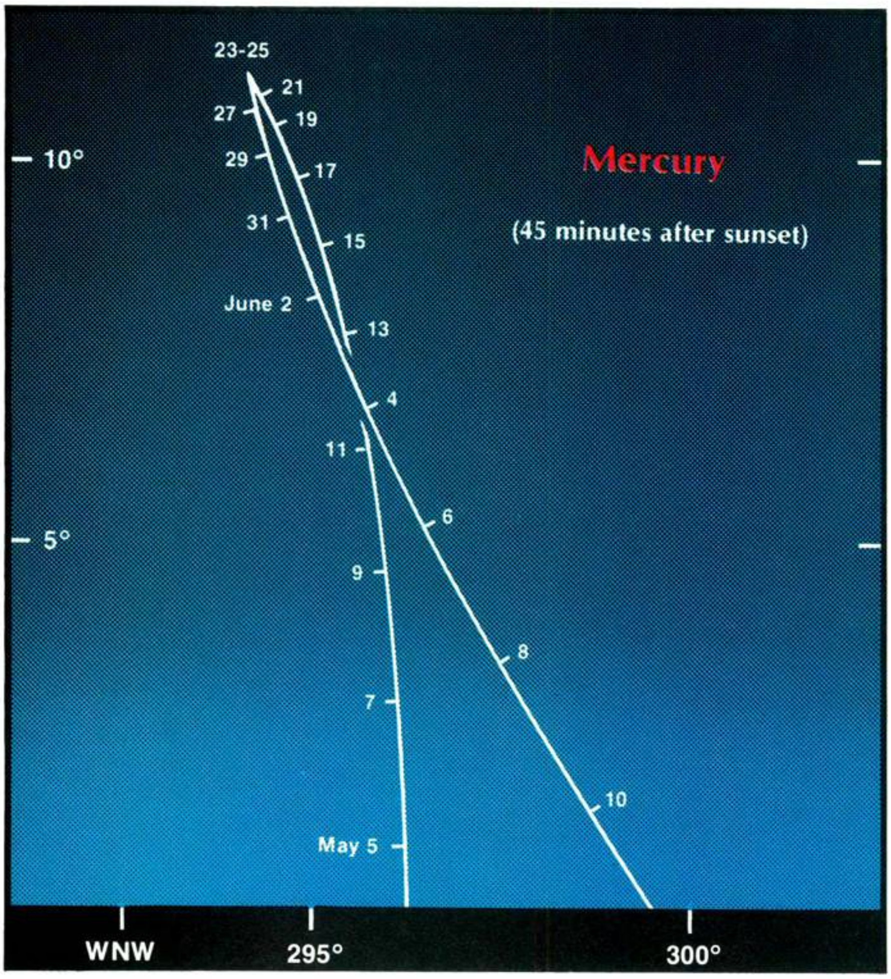
satellites of jupiter 6:00 ut



1	2304	16	023
2	10234	17	0243
3	01234	18	21034
4	21034	19	2014
5	23014	20	31024
6	31024	21	30214
7	3014	22	23104
8	24310	23	0134
9	4023	24	023
10	40123	25	42103
11	42103	26	42031
12	4201	27	43102
13	43102	28	43021
14	4301	29	43210
15	24310	30	4031
		31	41023

Jupiter = 0, Io = 1, Europa = 2, Ganymede = 3, Callisto = 4
(South is at top, matching the view in a telescope)

Auriga was rising on the northeastern horizon when Don Carney took this photo through the green tracery of an aurora. He used a 12-second exposure at f/1.8 on 400 ASA slide film which was then push-processed to 800 ASA.



The path taken by Mercury in the evening sky (45 minutes after sunset) before and after its elongation on May 27 is shown in this diagram (note its "standstill" from the 23rd to 25th). A latitude of 40° north is assumed, but the view won't be very different for most North American observers.

This year, the timing is superb: the Moon will be New and you should expect to see a good many meteors. The radiant (near the center of Aquarius) rises around 2 a.m. local daylight time, and the average hourly rate (at a dark sky site) is 20 meteors.

close-up on ursa minor/ draco

The circumpolar stars, by definition, never set. But the best time to observe in this region is still when it is at its highest, above the north celestial pole. Such a situation occurs this month for Ursa Minor and the surrounding serpentine constellation Draco.

The Little Dipper is much less prominent than its larger neighbor the Big Dipper, but the stars of its bowl are an excellent astronomical tool — we can use them to check the transparency (atmospheric clarity) of the night sky. The magnitude sequence is 2.24 for Beta (β), also known as Kochab, 3.14 for Gamma (γ), sometimes called Pherkad, 4.34 for Zeta (ζ), and 5.04 for Eta (η). If you can trace the entire Little Dipper with the naked eye, transparency is excellent.

Of all the objects in the sky, the only one that remains at almost the same position at all times is, of course, **Alpha** (α) **Ursae Minoris** — better known as **Polaris**, or the North Star. The reason for the "almost" in the last sentence is that in fact Polaris does not lie exactly at the north celestial pole. Instead, our North Star circumscribes a tiny circle less than one degree in radius around the pole every 24 hours (23 hours 56 minutes 3½ seconds, to be precise).

Polaris also happens to be a double star, consisting of a second magnitude, yellowish-white primary attended by a ninth magnitude blue-white companion some 18 seconds of arc away. Polaris itself is both a spectroscopic binary and a Cepheid variable, with a tiny variation in magnitude undetectable without special equipment.

A more readily visible variable star is **RY Draconis**, a reddish semi-regular variable with a period averaging about 173 days. During this period RY declines to one-ninth its original brightness, corresponding to a magnitude change of 2.4.

The next object in our table is **NGC-5866**, sometimes identified as M-102, but this is almost certainly a mistake. The *Becvar Atlas Coeli* labels NGC-5866 as M-102, but most scholars agree with the Harvard astronomer and historian Owen Gingerich that M-102 is simply a clerical error, corresponding to no real observations.

Still, NGC-5866 would make a respectable addition to the Messier list, being the brightest member of a small group of galaxies in the area. It appears as a small oblong (3′ x 1′) blur of light at about eleventh magnitude, with a group of several faint stars just to the north.

Psi (ψ) **Draconis** is a well-matched (spectral types F5 and F8) pair of fifth and sixth magnitude stars separated by a half-minute of arc in position angle 15°. Relatively fixed, these two stars share a common proper motion but no orbital motion has yet been detected.

Nestled within the first bend of Draco's body lies one of the brightest planetary nebulae in the heavens. This is **NGC-6543**, situated almost exactly at the north pole of the ecliptic. As it is only 22″ in diameter, you must sweep carefully to pick it up near the midpoint of a line joining the third magnitude stars Delta (δ) and Zeta (ζ) Draconis.

Although visible in a three-inch scope at 70x, the nebula is a much more striking sight in 8-inch and larger instruments. Its magnitude 8.8 blue-green disk contains an eleventh magnitude central star. Ten to twelve-inch telescopes at high power reveal complex internal detail in the form of intersecting rings of luminous material. The outer edge of the nebula has a distinctly asymmetrical outline.

40 and **41 Draconis** constitute a double star even more closely matched than Psi Dra. Separated in brightness by less than half a magnitude, the two stars have almost the same spectral types: F5 and F6. The pair is also closer than Psi Dra, only 19″ apart (in position angle 232°), but like our earlier double, 40/41 Dra is a relatively fixed common proper motion double.

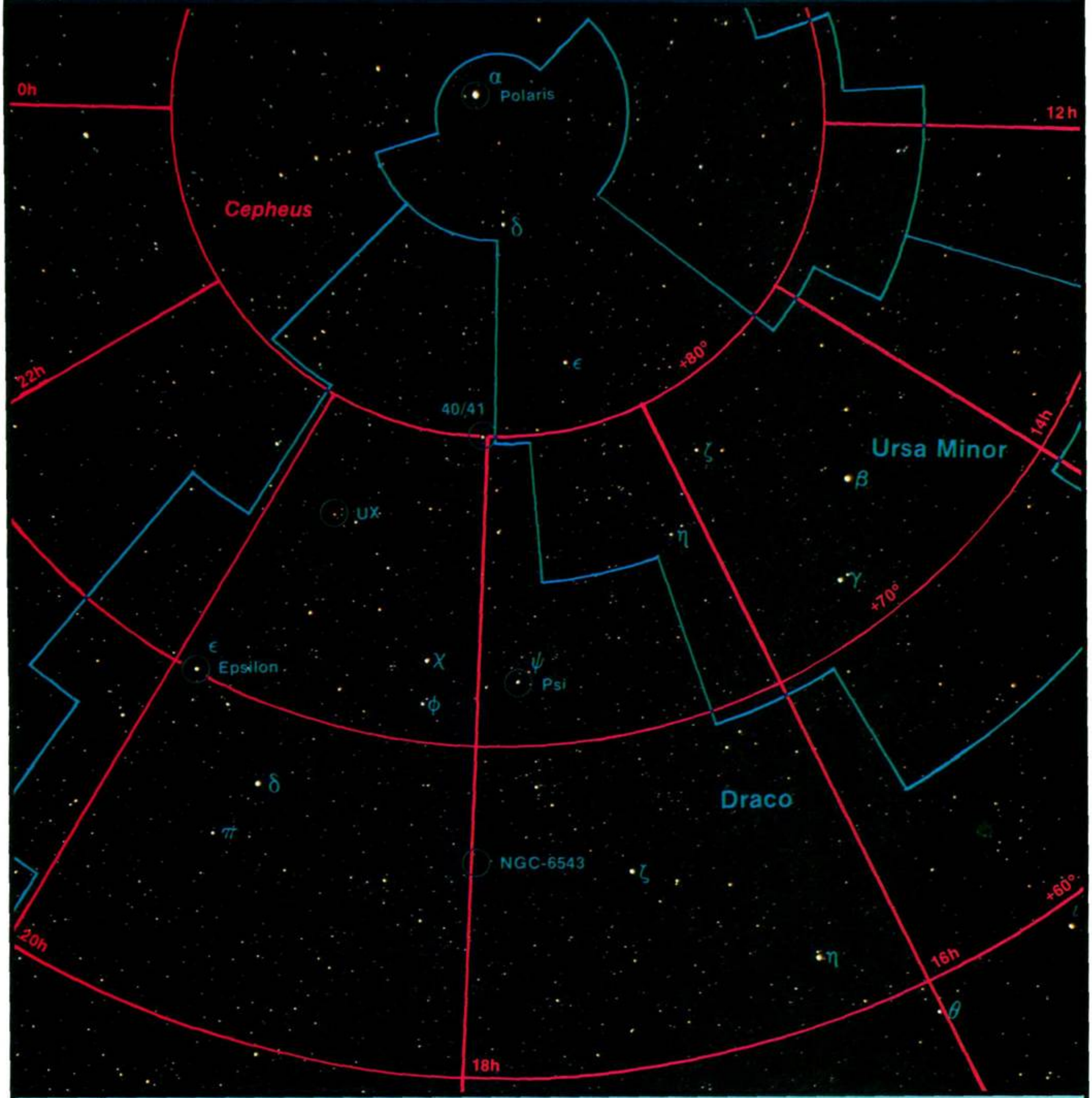
UX Draconis is a variable star with almost the same period as RY Dra but a larger variation in brightness. It can be found a little more than half-way along a line from Polaris to Delta Draconis.

Our last selection this month is another double star, **Epsilon** (ϵ) **Draconis**. Consisting of a fourth magnitude G8 primary attended by an F6 companion shining at magnitude 7.1 only 3 seconds distant, the pair make a pleasing sight at moderate magnifications. The position angle, listed at 15°, has been observed to be slowly increasing, but no definite orbital period has been established.

ursa minor/draco

Map by Dewey Schwartzenburg

Photo by R. Provin & B. Wallis


0h
α
Polaris
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Ursa Minor
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ζ
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Epsilon
χ
ψ
Psi
φ
δ
Draco
π
NGC-6543
ζ
+60°
20h
η
16h
θ
18h

Object	Type	Mag.	Size/Sep. Per.	R.A. (1950)	Dec.	R.A. (1981)	Dec.
Polaris	★^{2}	2.1, 9.0	18″	01h49m	+89°02′	02h13m	+89°11′
Y Dra	ო★	5.6-8.0	173d	12 54	+66°16′	12 56	+66°06′
NGC-5866	§0	10.8	2.8′ x 1.0′	15 05	+55°57′	15 06	+55°50′
Psi (ψ) Dra	★^{2}	4.9, 6.1	30″	17 43	+72°11′	17 42	+72°10′
NGC-6543	■	8.8	22″	17 59	+66°38′	17 59	+66°38′
40/41	★^{2}	5.8, 6.2	19″	18 04	+80°00′	18 02	+80°00′
UX Dra	ო★	6.2-6.9	168d	19 23	+76°28′	19 22	+76°32′
Epsilon (ε) Dra	★^{2}	4.0, 7.1	3″	19 48	+70°08′	19 48	+70°13′

★	*Star*
★^{2}	*Double Star*
★^{3}	*Triple Star*
ო★	*Regular Variable*
∩★	*Irregular Variable*
ӿ★	*Eclipsing Variable*
○	*Open Cluster*
●	*Globular Cluster*
■	*Planetary Nebula*
□	*Bright Diffuse Nebula*
§0	*Elliptical Galaxy*
§S	*Spiral Galaxy*
§ʃ	*Barred Spiral Galaxy*
§#	*Peculiar/Irregular Galaxy*

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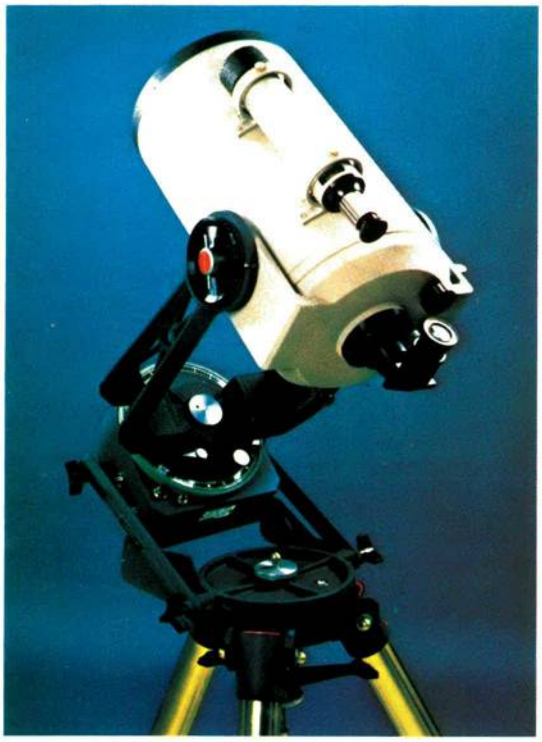
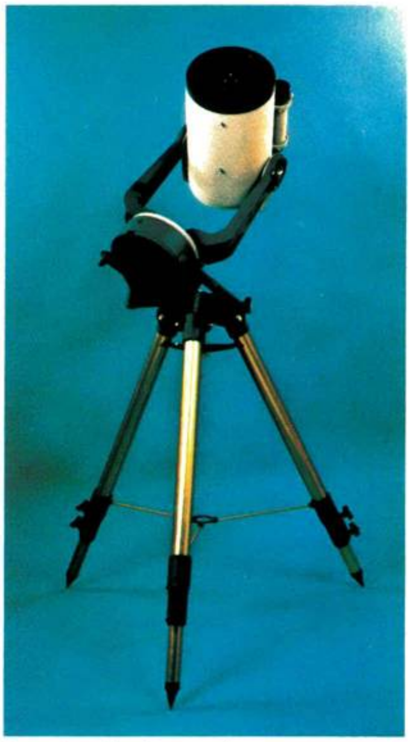


Rear view of the Dynamax 8 mounted on Dynamax Field Tripod



Front view of the Dynamax 8 mounted on field tripod

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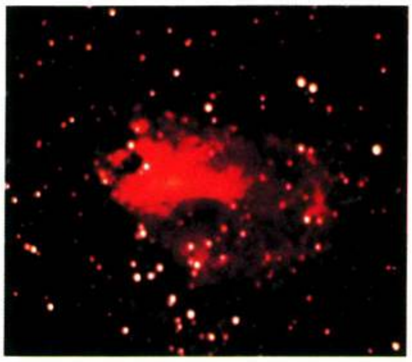
Due to the tremendous response to our recent price announcement we are extending the present price to orders postmarked prior to June 15, 1981. Effective June 15, the price will be increased to $949.95.



The Omega Nebula (M17) as photographed through the Dynamax 8.

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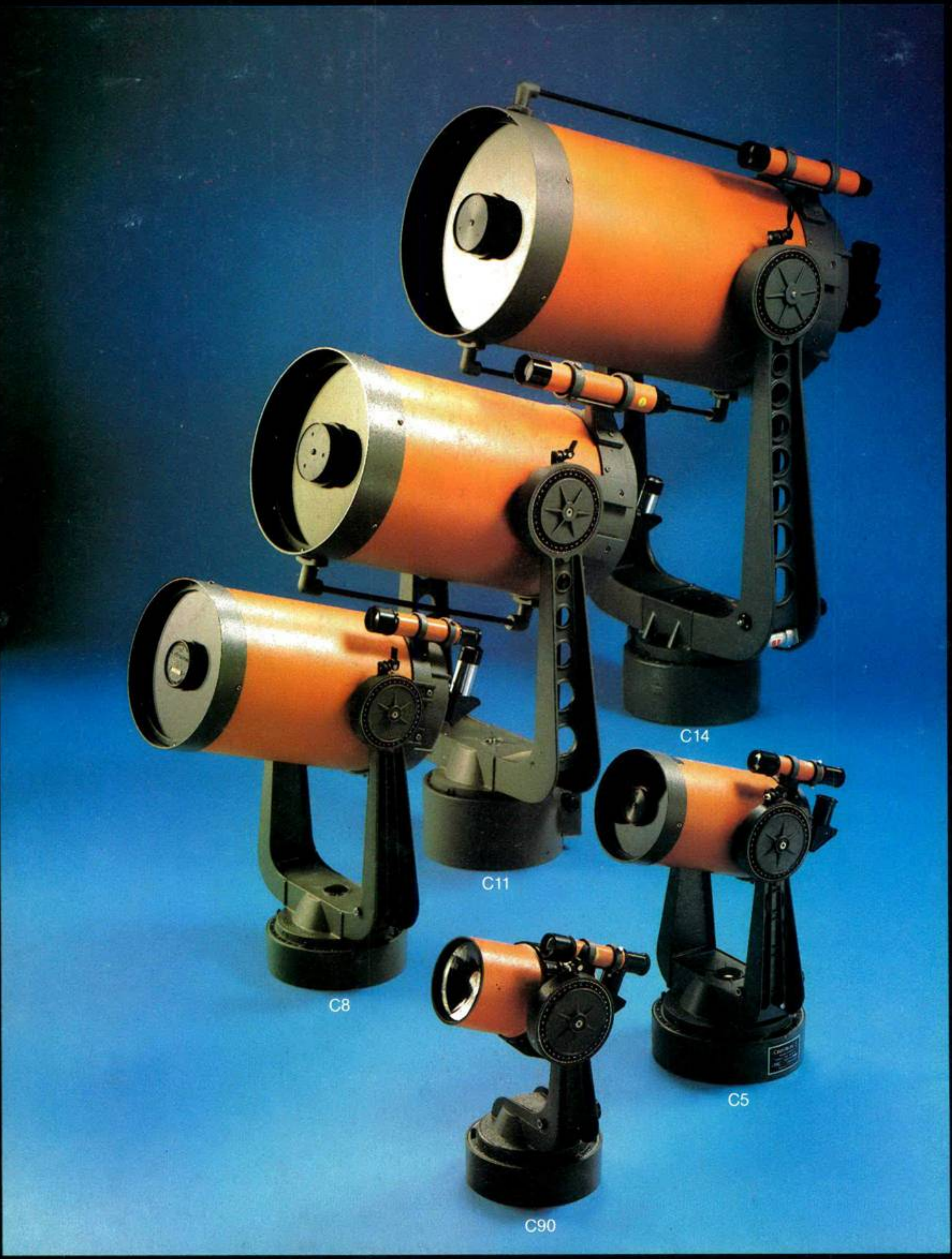

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